ABSTRACT

Title of Thesis:	HELTER SHELTER: RETHINKING DISASTER ARCHITECTURE AS THE FOUNDATION, NOT THE FEATURE
	Zain Shah, Masters of Architecture, 2019
Thesis Directed By:	Joseph Chandler Williams

Natural disasters are an ever-present threat to humanity, so why should there not be an ever-present solution? The goal of this thesis is to create a proposal for a new typology of structures that are designed primarily as permanent disaster shelters. These structures would focus on housing and defending evacuees during the initial stages of a natural disaster as well as provide services to those within it such as medical services, warm food and communication with those outside. This thesis to a lesser extent also will explore and critique current practices with assigning locations as disaster shelters by highlighting their failures and then provides solutions through the design of the final product. Finally, this thesis will define a potential solution through design explorations on a selected site in New York City's lower Manhattan. This project can act as a template for how future designers can create similar structures specific to their sites.

HELTER SHELTER: RETHINKING DISASTER ARCHITECTURE AS THE FOUNDATION, NOT THE FEATURE

by

Zain Shah

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Chapter 1: Introduction

In the current era there are many different types of threats that exist. Issues such as war, economic depressions and even job security are examples of problems that people hear about every day as oncoming disasters. In turn, it is easy to find these threats to a person's way of life as the world's most pressing topics. However, there are matters that are just as threatening that go unnoticed because of how they are perceived by the public. One such topic is that of large-scale weather phenomenon. Disasters such as these do not feel as threatening because although they are talked about in length when they do happen, they seemingly occur so infrequently that they do not need to be addressed until a major event happens. And yet, natural disasters are not as uncommon as many may believe.

In 2016 there were 750 natural disasters across the globe. From those combined disasters 9,200 lives were lost in the aftermath along with over $175 billion in damages[1]. Of that, the United States makes up 165 of those disaster events, with a substantial portion being caused by meteorological events such as storms and hurricanes.

[1] "Facts Statistics: Global Catastrophes." Facts Statistics: Global Catastrophes | III. Accessed March 29, 2018. https://www.iii.org/fact-statistic/facts-statistics-global-catastrophes.

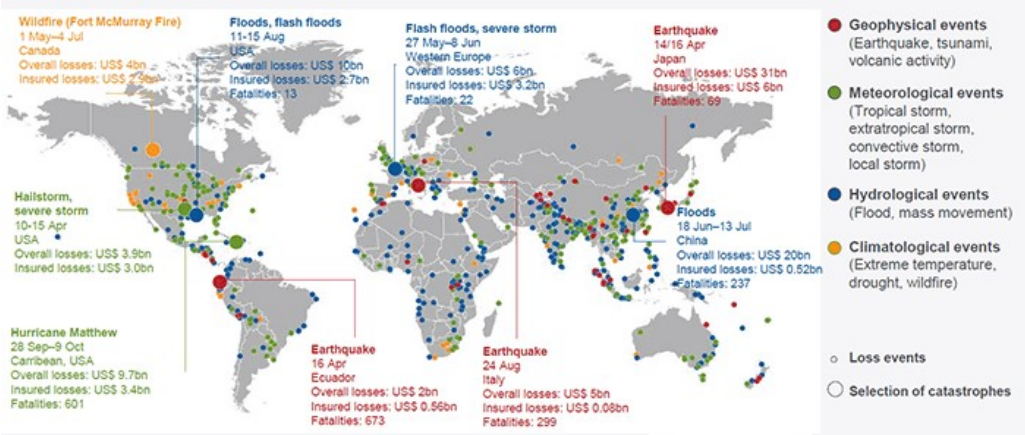

Figure 1: World natural catastrophes, 2016 (Source: Insurance Information Institute)

Figure 2: World natural catastrophes by type of event, 2016 (Source: Insurance Information Institute)

Figure 3: World weather-related natural catastrophes by continent, 2016 (Source: Insurance Information Institute)

Though public perception it may seem as though natural disasters are only relegated to “the one big one” that shows up once every year, usually shown on tv as a faraway threat. With over $57 billion spent on damages and 1104 causalities the data suggests however that while these storms are not only extremely dangerous, they are also growing in frequency. In the last 15 years three of the most costly and deadly hurricanes occurred on US soil, the costliest being Hurricane Harvey which occurred in 2017, the year this paper was proposed.

Faced with a literal force of nature humanity has attempted to mitigate as much damage as possible to prevent loss of both property and life. Levees and flood walls have established to prevent the rise of sea water and storm surges, buildings are constructed with methods of counteracting the tremors of an earthquake. However, this is not enough to fully stop a disaster; there is always the threat of what happens when one of these strategies fails.

New Orleans and Hurricane Katrina act as a testament to how one failure. can lead to a massive loss of life if proper disaster management methods are not in place to protect people. In a situation where images of families waiting on highways for rescue while others attempted to ford the flooded streets of their home circulated over mainstream media, a more vivid picture of a potential “worst-case scenario” cannot be painted.

Figure 4: New Orleans Citizens waiting for rescue on highway, feet from place of last refuge (Source: CNN)[2]

Faced with the reality of an increase in the need for protection from such events this project seeks to investigate not how to stop natural disasters but to design a shelter that helps prevent these "worst case scenarios." Using disaster management strategies to protect those who needed to seek refuge from such an event. The argument focuses on how designers can plan and improve a region's disaster planning not by designing for a city on mass, but by looking at and redesigning evacuation strategies and shelters for smaller, more manageable regions that take advantage of communities and communication to enhance disaster resilience.

[2] https://www.cnn.com/2013/08/23/us/hurricane-katrina-statistics-fast-facts/index.html

From Shelter to Community Center

The solution proposed is to find a way to react to two parts of natural disaster defense; how do shelters protect the citizens from natural disasters and how can they help to reestablish the lives of those effected. Having a place that can act as a place of refuge in a worst-case scenario is only one part of the problem. It is also important to make sure that the shelters provided not only aide those effected physically, but also psychologically. It needs to provide a sense of safety as well as provide a means to create that sense of safety through services such as food and water.

It is also important that a shelter was realistic in how it was implemented. A location that was a shelter for natural disaster at all its lifecycle was unrealistic; it was not practical to have a single location never used and only for natural disaster defense. However, it would be counter to the core philosophy of this argument for the shelter to be something that was not easily convertible back into said shelter at a moment's notice. To this end the project took the form of a community center that was primarily designed to act as a shelter when it is needed.

The choice was made for what a community center could provide for the community it served. Such a space would have many programmatic elements that would be practical and easily convertible for a shelter space. For instance, if the center had a gymnasium with a locker room this space could provide not only living quarters but also a place for occupants to take daily showers and stow personal items.

For this argument a Shelter that took the form of a community center worked for the goals of this argument, however in future any designers attempting to do similar should consider why it was chosen, not only for its programmatic benefits.

There is the case to be made for the psychological benefits to a community center. Such a space could act as neutral ground for all occupants that could, if designed properly, act like a second home. By having a place that the users felt at home in it would lessen the psychological blow of losing their own.

Finally, such as space would be an easily recognizable place for those living in the area. People would be able to much more easily locate the shelter since it is a part of their daily life and in turn it would be easy for a shelter to be able to disseminate information about safety and evacuation plans to those who used the space regularly. If future designers were to build their own shelters in their respective communities.

Why Defense over Mitigation

One of the main critiques of projects like this are that they act as a response to a problem that is a symptom of a much larger one. The issue in question is the continued development of our cities into land that we know are likely to come under threat to natural disasters. In the modern area resorts and low-income housing are built in areas that are prone to flood, communities settle in tornado alleys and entire cities are established near fault lines. These threats are not only the reality, they are the norm when it comes to development. Those who live in San Francisco[3] live under the constant threat of a mega-earthquake, colloquy known as "The Big One," that could one day decimate a large portion of their city in the coming years. There are signs that can be seen today that the mega-earthquake is inevitable as the fault lines

[3] https://www.latimes.com/local/lanow/la-me-ln-tour-san-andreas-fault-lucy-jones-20170613htmlstory.html

move and disrupt the earth along their path of travel like a snake coiling to strike. With the clear threats that natural disasters oppose should not then the argument being made by this project be that these vulnerable communities should be relocated to safer locations? The argument is not an invalid one, in fact it is something that is paper acknowledges and agrees with. It is clear that populations are at risk of natural disaster events, and that in an ideal scenario all communities would cease development in these zones. However, unfortunately this mindset has several flaws.

The first issue with this line of logic is that the number of people in the world is growing. Even with the decreasing growth rate of the human population the world population is still growing and by 2100 the world population would be around 11.2 billion people. As this number increases so does the need for homes and infrastructure to support them. With such growth it become only inevitable that developments will begin building in risker and risker areas as safer locations become sparse. In many cases we may see poorer demographics being pushed into these areas as we have seen all throughout history making it even more imperative that there be some way to defend their vulnerable populations.

With the number of people growing there is also the issue of where will those who are currently settled go? The current population must contend with issues discussed prior currently and have set up their lives in these established communities. Those arguing large scale solutions to this problem must then propose how they can move these populations without completely disrupting their lives, as well as where they will all go.

While these issues exist, there are more than likely solvable through good logistic planning and with time given for the plan to be implemented. However, what is important here is the time aspect. For any plan to be implemented those pushing for change must not only change public perception of how important an issue natural disaster is, but also must find both the financial and political support to implement any change. In that time those people who live in these risk-prone areas will continue to be threatened by natural disasters that potentially could and will happen.

It should also be highlighted that this time period is an unknown; there is no way to accurately predict how long it could take to create, fund, pass and preform a relocation effort. In that time the number of disasters will continue to rise and with it the casualties both in physical damage and in loss of life. The formulation of this project came not only from wanting to mitigate a real issue, but also from realizing that any large-scale plan would take time. By developing smaller projects that could more adult be funded and implemented this project works to find a way to help as many people as possible as quickly and safely as possible.

It is acknowledged that this may be only a temporary fix, but the argument that instead of trying to find a way to save lives now instead of more down the line is short-sighted in its approach. And there is no reason both plans cannot be establish in tandem, this paper only argues that the methods currently used do not provide the best possible solution to defending our most vulnerable populations from disasters.

The Disaster Management Cycle and The Shelter

There are four stages to disaster management; Mitigation, Preparedness,

Response and Recovery[4]. The shelter will focus on stages two and three, Preparedness and Response, or in other words how communities prepare for, communicate, and react to a disaster. The thought process is as such; in many cases cities are aware of their susceptibilities to natural disaster and have devised strategies to mitigate or protect against them. In places like New Orleans levee systems were constructed to protect against the assumed threat of flooding based on geological data and historical experience. However, in many cases it has been shown that individuals who need not evacuate not only have issues receiving proper evacuation instruction, but also have trouble trusting or judging whether they need to evacuate[5]. In these very real scenarios, a disaster can have extreme consequences because the chain of commutation and the preparedness of a community can lead to large-scale loss of life. When this failure leads to this outcome it is the most socially vulnerable parts of the city that are the most affected; those who are of a lower economic level or class, those who are of a minority group, those who are elderly or children, as well as many other social groups are both physically and mentally affected by improper preparedness and response by officials[6]. Taking this truth and the argument that in the event of a worstcase scenario shelters need to be designed for these occasions.

[4] Flanagan, B. E., Gregory, E. W., Hallisey, E. J., Heitgerd, J. L., & Lewis, B. (2011). A social vulnerability index for disaster management. Journal of Homeland Security and Emergency Management, 8(1).

[5] Phillips, B. D., & Morrow, B. H. (2007). Social science research needs: Focus on vulnerable populations, forecasting, and warnings. Natural Hazards Review, 8(3), 61-68.

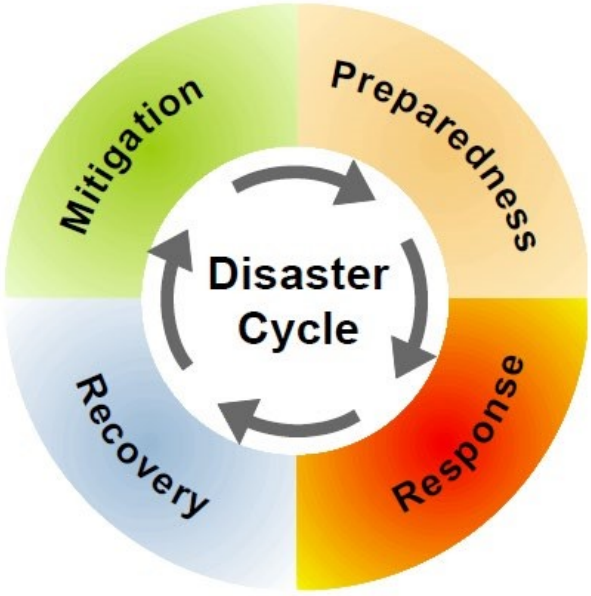

Figure 5: The Disaster Cycle (Source: Flanagan)[6]

To understand why these were important data was collected on how much time is given to an individual when an event is predicted. With hurricanes predictions can be made quite early thanks to metrological data. Early pathing can be soon as 5 days before a storm, however most states in the United States start to give evacuation orders in phases until the data becomes more reliable, such as a storm watch to storm warning[7]. Usually within 48 hours any full-scale evacuation will be in effect, however this is a limited time window. It is also within this 48 hours that civilians are required to make a decision that could mean either they need to leave their homes and disrupt their lifestyle or potentially lose their life. This process is a seven-stage

[6] Flanagan, B. E., Gregory, E. W., Hallisey, E. J., Heitgerd, J. L., & Lewis, B. (2011). A social vulnerability index for disaster management. Journal of Homeland Security and Emergency Management, 8(1).

[7] Samost, Aubrey. "Predicting Hurricanes: A Not So Exact Science." Predicting Hurricanes. Accessed March 29, 2018. http://web.mit.edu/12.000/www/m2010/teams/neworleans1/predicting hurricanes.htm.

process in which involves people getting the message, confirming in, and then deciding if it is possible for them to even evacuate or if they should risk it and stay home[8]. With factors such as how people evacuate as well as where they will all go; this issue needs to be investigated and expanded on.

It is also somewhat presumptuous that evacuation will have a 48-hour window in which people will have this warning. There are some events cannot be predicted; earthquakes and tsunamis cannot be predicted, but can be detected[9]. A tsunami, can be detected through buoy systems which can sense an oncoming event and give a general idea of where the waves may head. In a scenario such as this, it is important to understand that a tsunami can cross the North pacific in under 24 hours given a high enough magnitude. In these situations, having a place in which people and quickly evacuate to at a moment's notice would be imperative to protecting human life.

Understanding the Importance of Home

There is also the argument to be made for the psychological damage of a disaster. Natural disasters also have a profound effect on the lives of those who must deal with them. Those evacuating areas soon to be affected leave their home knowing that there is a chance they will never return. They are also subjected to multiple stressors including loss of income, safety and potentially loved ones. In many cases women have been found to have it even worst; where men find themselves being

[8] Phillips, B. D., & Morrow, B. H. (2007). Social science research needs: Focus on vulnerable populations, forecasting, and warnings. Natural Hazards Review, 8(3), 61-68.
[9] NOAA. "NOAA's National Weather Service." Pacific Tsunami Warning Center. March 13, 2007. Accessed March 29, 2018. http://ptwc.weather.gov/faq.php.

picked to help in reconstruction women tend to be forced into an inactive role to protect the children if they have families or are subjected to increased physical and mental abuse by males in these scenarios. Children find it difficult to cope with the chaos of the situation, and family members begin to neglect them as they worry about safety and food, or in some cases where they are orphaned by the disaster they suffer even more stressors and trauma. Questions such as where a person will sleep or where they will get their next meal become the most important question to answer as that sense of stability in their lives are removed.

In researching how to better define this phenomenon Maslow's Hierarchy of Needs became a way of describing this loss. To put it simply, this theory of psychology defined by Abraham Maslow in 1943 helps to understand what a person needs to motivate themselves and to continue to move forward. There are three categories of Needs going from "Basic Needs" such as food and safety to "Self-fulfillment Needs" such as self-actualization.

The loss of home removes what are defined as the "Basic Needs" of an individual as there is both a loss of safety needs and a loss of physiological needs. In everyday life most people deal with the "Psychological Needs" and the "Self-fulfillment Needs" as most people live in a home where they can attain the basic level. After a natural disaster the loss of home removes those "Basic Needs"; people need to be able to attain food and water, as well as warmth and rest to motivate themselves to continue in life. By removing this level of needs via a natural disaster individual are forced to re-motivate themselves to by reestablishing this base, as per Maslow's theory which says that one cannot ascend to the next tier of needs on the

pyramid unless all the conditions of the lower tiers are met. It is the belief of this thesis that this theory holds true and that in a time of crisis a natural disaster shelter needs to help the individuals it protects to reestablish these bases.

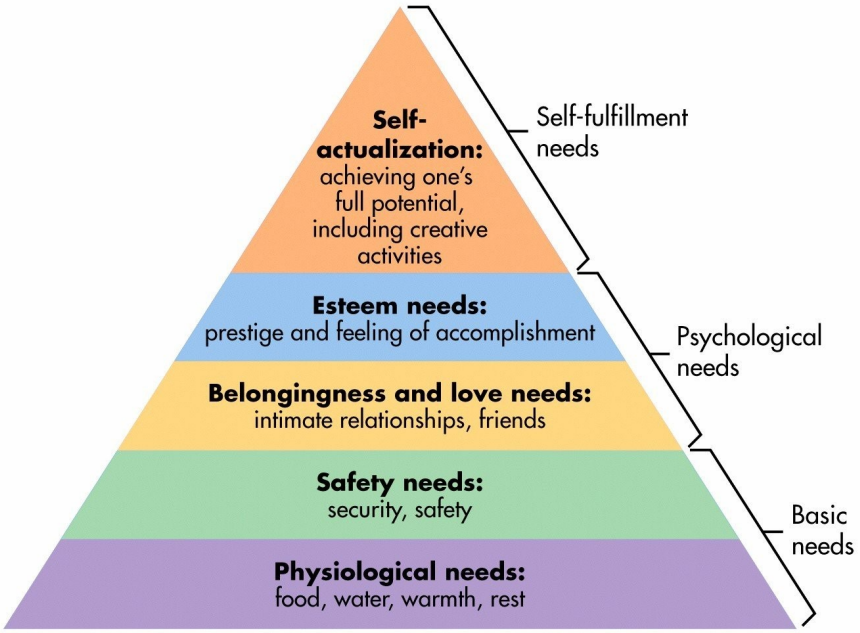

Figure 6: Maslow's Heirarchy of Needs (source: Mcleod)[10]

Final Parameters

Moving forward with the design the thesis had a clear end goals; design a shelter that primarily defended a community from natural disaster, while at most times it was a community center. The space needed to not only defend the citizens from danger it needed to be a location that felt like a second home. It also needed to help reestablish the "Needs" of those using by providing spaces and services that met the requirements defined by Maslow's Theory of Needs.

[10] Mcleod, Saul. "Maslow's Hierarchy of Needs." Simply Psychology. Accessed March 29, 2018. https://www.simplypsychology.org/maslow.html.

Chapter 2: Site Selection and Evaluation of Evacuation Protocols

Selection of New York City as Case Study

The argument of this project is that shelters should be designed to fit for the location and the people they are built to service. This being the case, any site within a disaster-prone area would potentially be an acceptable test location for the project, however after consideration the site that was chosen for this case study was New York City, Specifically Manhattan.

There were several reasons why New York was selected over other, more well-known locations of natural disasters. The first reason was that unlike many other, more well-known sites New York is a city is not somewhere that many would consider to be a natural disaster threat. However, looking at the data, it has the potential to become a disaster location. Looking at the state by state guide to Disasters created by FEMA New York City is zoned to be vulnerable to disasters such as earthquakes, Hurricanes and Flooding[11]. It is the goal of this project not only to highlight how we should change the way designers and planners think of natural disaster defense, but also change the mindset of how truly vulnerable much of the US is to natural disasters currently. Selecting New York City was done to prove that the truth is that disaster can hit anywhere at any time.

In fact, many may have forgotten but New York City has been the site of a natural disaster as early as 2012. Only a few years ago Hurricane Sandy caused massive amounts of flooding and damage to the city that left many without homes or

[11] United States. Federal Emergency Management Agency. 1990. Risks and Hazards : A State by State Guide. Washington, D.C: Federal Emergency Management Agency.

without power for some time.[12] The effects of Sandy will be discussed further in Chapter 3, but the historical significance acts as a reminder that it is likely to repeat itself if not with more effect. It is important that designers and planners recognize threats such as these and plan accordingly.

New York City also provides a few design constraints that many growing cities will one day face. In the US New York is the densest city in terms of population. As of the 2010 census the density of New York was estimated to be 28,491 per square mile[13] with Manhattan having the largest density of all the boroughs. This fact is also accompanied by the fact that Manhattan is almost completely developed, leaving not much room for any large facilities. These two factors, a large and dense population to serve and minimal developable land creates constraints that designers must be aware of as the US population grows. In many situations this will become the norm when designing as those tasked to plan for disasters must consider that New York's reality may become the same for their site as well.

With these factors in mind it can be seen that New York is much more of a viable and in fact important site for this prototype to take place in that what one might think. If New York could successfully become more resilient to disaster while accounting for the issues stated above, then future designers could take the lessons learned here and apply similar logic to solve their site's specific goals. With the city

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[12] Zerkel, Eric. 2014. *"Superstorm Sandy Anniversary: Remembering Hurricane Sandy Two Years Later,"* The Weather Channel.

[13] https://www.census.gov/quickfacts/newyorkcitynewyork

site chosen, it is now important to discuss where within it the prototype would be constructed and why.

Site Selection

The limiting factor of developable land in New York meant that it was unlikely to find a site with an empty lot large enough for the purpose of sheltering. It is because of this that the location that was selected would have to be an existing building that could be repurposed for the shelter. But to find this building a site that would provide the best-case study for the prototype would need to be found. The first factor to take into consideration is where would be the most likely location for a disaster.

There are two methods that are at designer's disposal that can be used to find where they should be looking for where disasters could take place. The first, and easiest is to look at the evacuation plans for a city for their most common natural disasters. Many cities in the modern day have such plans that are readily accessible to the public and in some cases will highlight where people are likely to be affected. This can help to make the selection of where a shelter could be built by placing it with walking distance of an evacuation zone. In the case of New York City such plans can be found on the cities website under the emergency management section.

The other method would be to use data from previous disasters and use the data, such as previous locations, to develop a map of where a disaster could take place in future. It is fortunate that New York City had both readily accessible. By comparing a map showing the damage caused by Hurricane Sandy to Manhattan's

evacuation plan it was found that the south end of Manhattan, especially around the coast, would be the largest target for disasters.

Figure 7: Evacuation Zone compared to Sandy Damage (Source: Zain Shah)

Next, for the purpose of the prototype, taking those areas that were prone to disasters, it becomes important to further narrow down which population would need this shelter the most. In the case of implementing this method for another city

planners would need to divide the city into smaller population groups and provide a shelter for each segment, however since this prototype would be a protype it focuses only on one extremely vulnerable population that it would be servicing. To find said population it becomes important to understand what makes a population vulnerable.

There are several characteristics that can be used to identify a vulnerable population. The first of course is the geographic location. Locations that are close to coasts, or near fault lines are of course vulnerable to disaster. For site selection it was already discovered where those locations were. There are several more involved factors that can be used but to summarize they will be called 'demographic factors.' When looking for populations that are vulnerable similar factors can be found between them, some which could be said are affected by one another. Factors such as Class, Race, and Economic levels are such factors. Researchers have found that poorer neighborhood tend to have difficulty in all aspects of the disaster cycle, including response and recovery[14]. Cases also have been made that populations that have a high concentration of minorities tend to have a harder time recovering from disaster[15], this being caused by cultural factors such as how local governments were connected to these populations as well as similar economic situations that made

[14] Fothergill, Alice, and Lori A Peek. 2004. "Poverty and Disasters in the United States: A Review of Recent Sociological Findings." Natural Hazards : Journal of the International Society for the Prevention and Mitigation of Natural Hazards32 (1): 89–110. doi:10.1023/B:NHAZ.0000026792.76181.d9.

[15] Wright, Beverly. 2011. "Race, Place, and the Environment in the Aftermath of Katrina." Anthropology of Work Review 32 (1): 4–8. doi:10.1111/j.15481417.2011.01052.x.

recovery more difficult than in other, more majority areas. Using these factors finding vulnerable populations was simple, in fact it was extremely visible when looking at information graphics.

Manhattan has a large amount of people with a high median income. As of 2012 most of Manhattan had a Median Income of $68,000 or more. While this is the case, there is an area of Manhattan has a clearly lower amount of income, this being the area of Chinatown. Chinatown has a median income ranging from $24,000 to $53,000 creating almost an economic barrier between it and the rest of the city to its north and west. Chinatown also has as the name implies a large portion of its population being Chinese and other minorities, meeting another of the factors that many vulnerable populations have. Finally, much of the residential portion of Chinatown falls into the evacuation zone of Manhattan, but there is a portion within the safe area that could act as a reasonable location for the shelter prototype to take place.

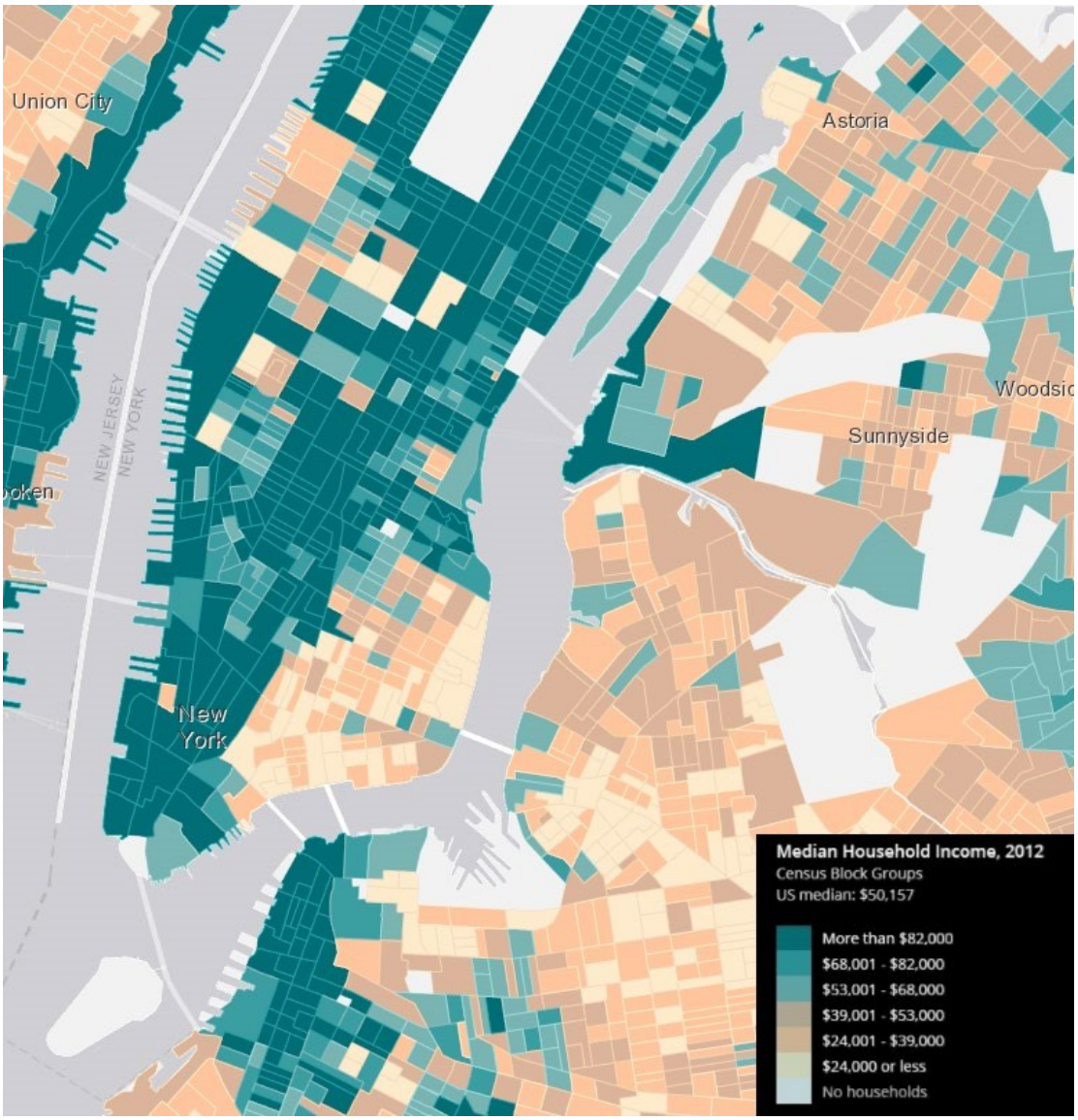

Figure 8: Median Income in Manhattan (Source: Zain Shah)

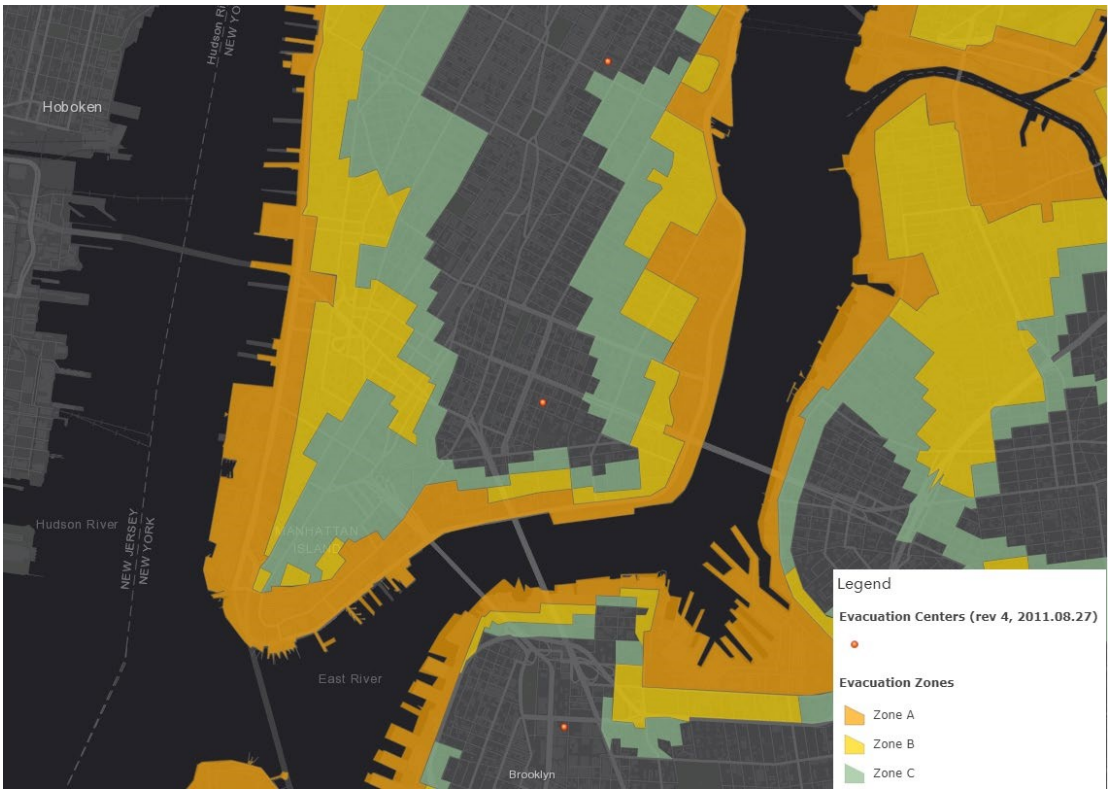

Figure 9: Manhattan Evacuation Zones (Source: Zain Shah)

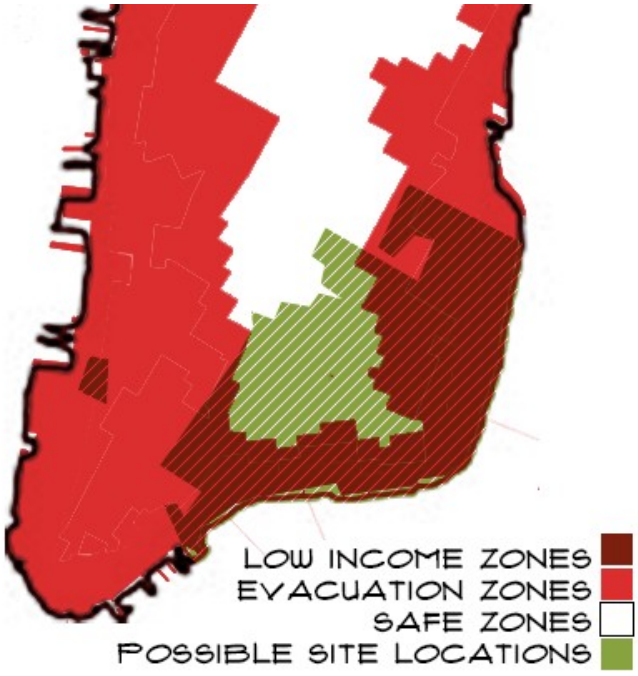

Figure 10: Final Possible Site Locations (Source: Zain Shah)

Selection of Chinatown Site

Having selected Chinatown as the site, a location for the shelter was selected, that being the current day location of New York City Housing Authority's Henry Rutgers. Henry Rutgers is a multi-family elevator building owned by the NYC Housing Authority. Currently the apartment complex fits on a lot of around 40,000 sq. ft with 14 floors and 104 units[16]. This a public housing development provides a low-cost housing to those who meet specific requirements and need housing. The service provided is quite important, so why would we use this site to develop the shelter prototype?

Figure 11: 45 Allen Street, 10002 (Source: Zain Shah)

Unfortunately, developments such as these are declining; currently the

[16] NYC Planning. "ZoLa NYC's Zoing & Land Use Map." Zoal.planning.nyc.gov. https://zola.planning.nyc.gov/lot/1/307/1#17.02/40.715968/-73.991491 (accessed December 10, 2018).

NYCHA have difficulty maintain these apartments, which leaves much of these building in a sad state[17]. A site visit shows that the exterior of this building itself shows a bit of what this is like, showing the wear and tear of neglect. This creates a new design constraint for the prototype, that being how can we maintain the existing 104 units? Can the shelter work with the current complex, or does it need to create a new facility all together to use the lot more economically and provide a better living situation to those who are already there? This problem is further discussed in the design section of this document

Discussing some of the factors as to why this site was chosen of all other locations it begins simply with location. This apartment complex fell well within the safe zone for Manhattan while also bordering the residential section of Manhattan. Since the shelter would function as a community center when not in use having to being within proximity to a residential area only made sense to its design.

[17] Board, Post Editorial. "The Slow Death of New York's Public Housing." New York Post. February 20, 2017. Accessed December 22, 2018. https://nypost.com/2017/02/19/the-slow-death-of-new-yorkspublic-housing/.

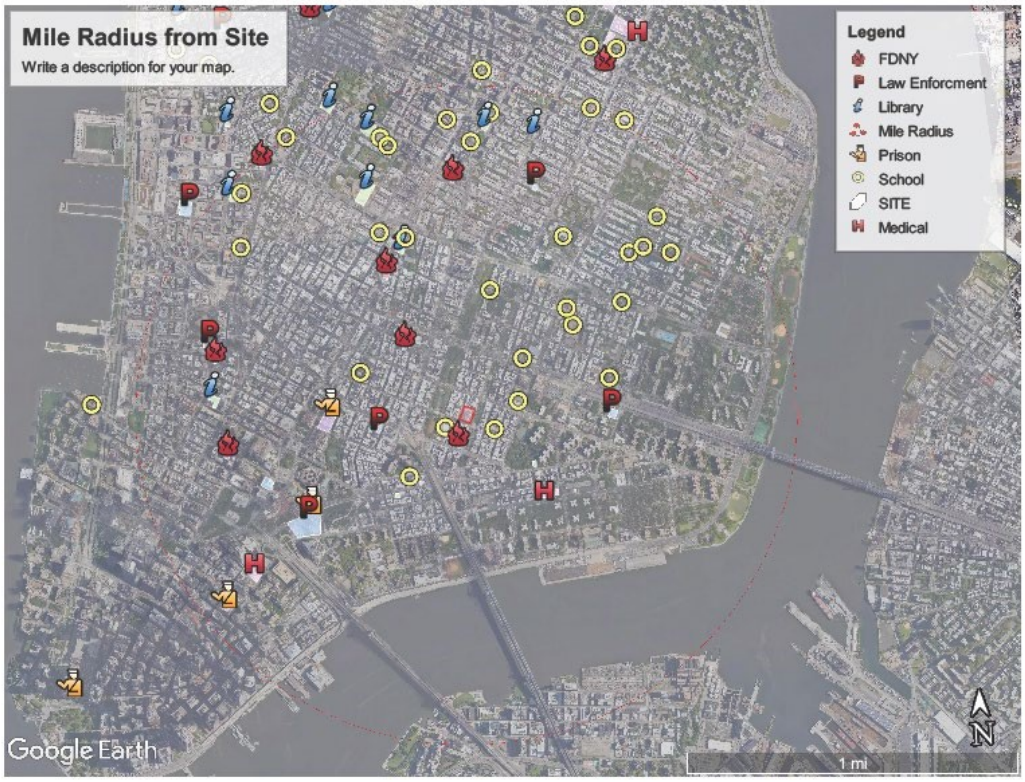

Figure 12: Facilities Near Site(Source: Zain Shah)

Figure 13: Important Spaces in proximity to Site (Source: Zain Shah)

This was further compounded the neighborhood it was within. Looking at the surrounding area Henry Rutgers was next to PACE High School, Multiple Outdoor play spaces such as tennis courts and basketball courts. These spaces not only made this an area where children and families might be expected to use often, but also provided several locations that could be used as temporary outdoor facilities after a disaster event occurs. There is even a small green walkway on the south east side of the facility that could be acknowledge in a design to help extend the borders of the community center aspect outside of its physical lot.

The side also provided multiple avenues for the population to move around the city. Unlike with many other locations Manhattan is somewhat unique in that most of the population does not have a vehicle. The main method of transit is by subway, taxi or bus. Henry Rutgers is places in a location that is within walking distance of two metro stops and two bus routes that can help move the population in the event of a disaster.

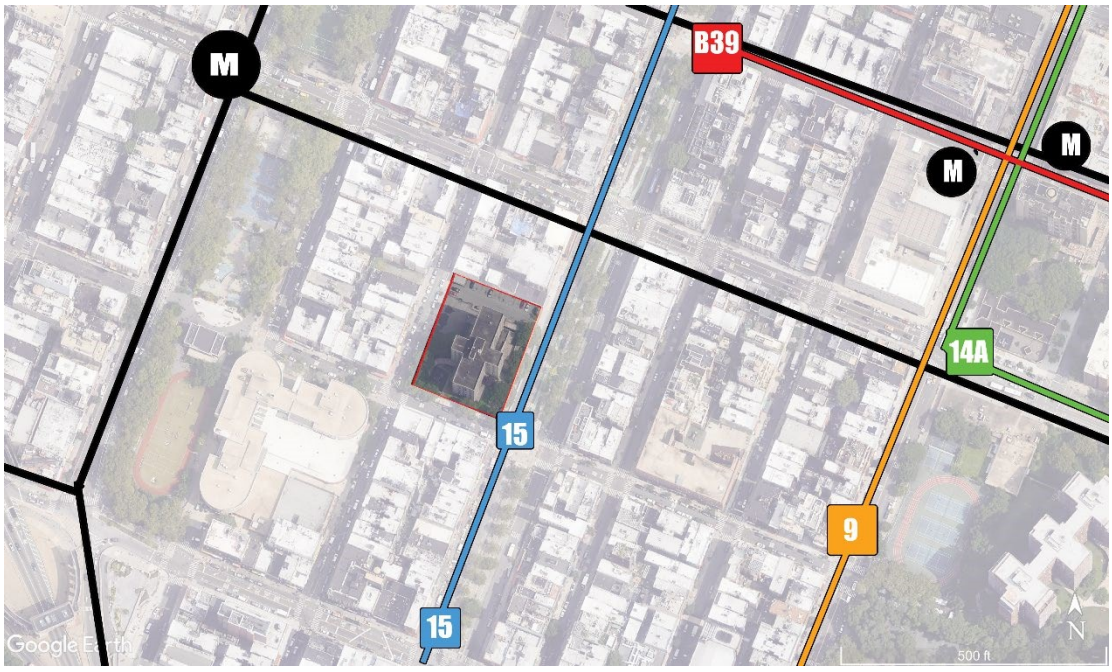

Figure 14: 45 Public Transit to Site (Source: Zain Shah)

The Purpose of Evaluation

In order to understand what needed to be fixed and what areas we could adapt New York needed to be evaluated in terms of their preparedness for an natural disaster. In the last chapter areas that needed to be considered in design were defined, and by considering how New York City does its evaluation it can be seen which areas need improvement and what can be left alone.

Evacuation

Zoning and Accessibility

After events such as 9/11 and Hurricane Sandy the city of New York realizes that there needed to be a more structured plan in place for the city. For each type of disaster that New York could potentially fall to simple instructions and plans were created for citizens to be able to know what they needed to do to say safe. Overall this information is quite accessible; all the information is available online via the New York City government website and is available in multiple languages and format that is clear and concise[18]. Unlike with Katrina, New York realizes that communicating this information clearly is just as important has having a plan for said disasters.

With evacuation proper it can be seen that New York has taken a tiered zoning approach. Areas where flooding was seen during sandy have been expanded upon

[18] http://www1.nyc.gov/site/em/ready/hurricane-evacuation.page

along the contours, creating various stages of evacuation in a natural disaster were to take place. There are 6 levels that are evacuated in order as severity and likelihood of a disaster hitting increases. Much like the information on evacuation these zones are easily accessible via an interactive map which also highlights the different shelters in the area. What is also a positive of the city's preparedness is that the city promotes the zones actively; there is a promotional slogan, "know your zone", which is apart of a campaign to make citizens aware of what evacuation zone they are in as well as inform citizen of where they can find this information. The city also gives out free zone designation stickers to businesses so that customers can subconsciously learn what zone they reside in and to make the information more commonplace.

These are extremely positive and forward-thinking policies that the city of New York as instituted. The city has planned for the worst-case scenario in terms of the logistics and clearly communicated the plan to citizen, which was one of the serious topics with the recovery of Hurricane Katrina. However, there are still some critical issues that were realized through researching the evacuation strategies in earnest. There are still some significant questions in how people are expected to evacuate in a natural disaster that need to be better thought about as will be highlighted in the next few subsections.

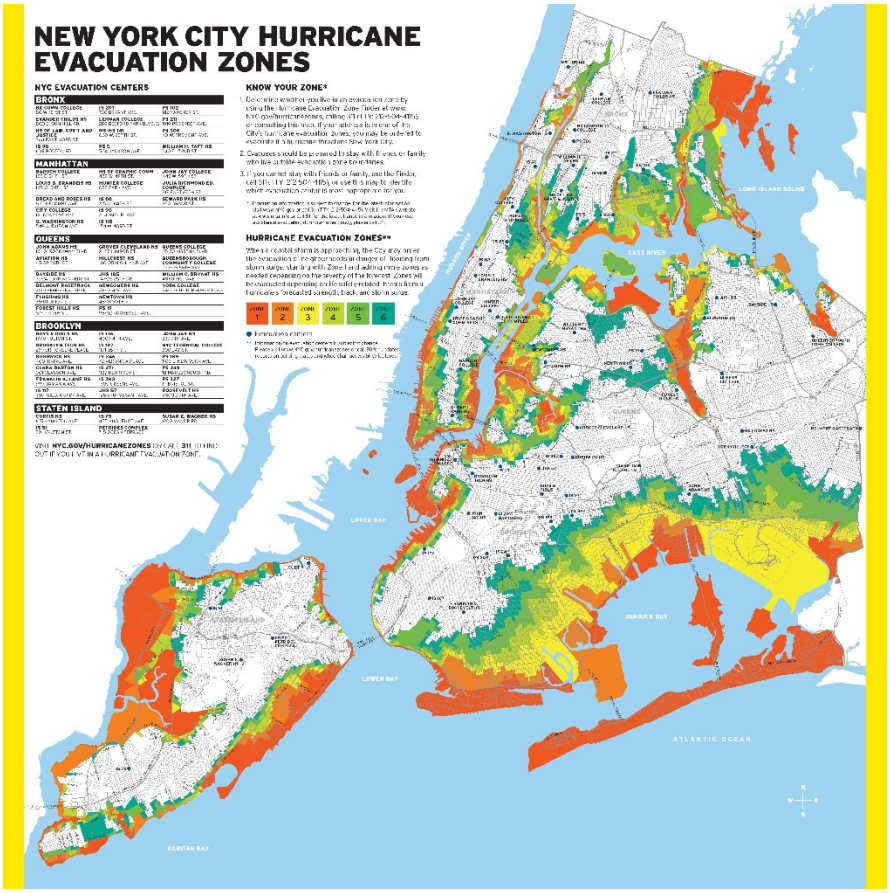

Figure 15: Evacuation Zones of Manhattan (Source: NYC.Gov)

Road Transit

As an Island the issue of getting out of Manhattan in the event of a natural disaster was investigated. Because there are no physical connections infrastructural elements would need to assist those attempting to leave. In terms of vehicular evacuation there are 19 exit points consisting of tunnels bridges and toll roads. Of those seven lead back into areas such as Queens and Brooklyn which would also be evacuating to higher ground or further away from the coast towards the North and North West. The limited amount of ways to leave Manhattan creates an issue because it would create congestion as people attempted to leave. These areas become chokepoints where large volumes of people will be trying to reach, which in turn can lead to large scale traffic if a large volume of people were to leave at once. Thankfully, the

city of New York had the foresight to plan for this; in their evacuation recommendations New York recommends that personal vehicles not be used for this exact reason.

> The City advises against car travel during an evacuation. The City will be working hard to keep roads clear, but traffic is unavoidable in any evacuation. Driving will increase your risk of becoming stranded on a roadway during an evacuation. Be ready for a long, slow trip. Be aware the City will deploy public safety personnel along major transportation routes to help vehicular traffic flow as smoothly as possible. Have a full gas tank before you go. Evacuation route signs point the way to high ground, away from coastal flooding. If you must evacuate, leave your home before storm conditions make roadways unsafe[19].

The city acknowledges the risk that the risks that driving can have for those leaving as well as others attempting to leave, however there will still be those who attempt to do so. Luckily, Manhattan has a low population of people who use personal vehicles, but even so public transit has its own issues.

Subway and Railway Transit

Evaluations of the New York City Subway lines also yielded a similar conclusion. A large majority of the population New York does not own a personal vehicle. In fact, less than 25% of those living in the Manhattan area own a car, making public transit the preferred method of transit. New York City has an expansive network of subway lines that help to create easy connections across the city with the stations primarily the stations are grouped

[19] NYC Emergency Management. "Plan for Hazards." New York Government. Accessed December 20, 2018. https://www1.nyc.gov/site/em/ready/coastal-storms-hurricanes.page.

within the center of the cities. This allows for the city to be able traversable for those wishing to get from one city block to the next without dealing with traffic. In fact, the New York City Emergency Management's Hurricane Evacuation Plan listed the following in regards to public transit:

> Plan to use mass transit as much as possible, as it offers the fastest way to reach your destination. Using mass transit reduces the volume of evacuees on the roadways, reducing the risk of dangerous and time-consuming traffic delays. Please note that public transportation may shut down hours before the storm.[21]

Figure 16: NYC Map (Source: NYC Emergency Management) This method of evacuation from at-risk zones made sense in terms of moving people further into non-flood areas, however some issues immediately become apparent when evaluating the viability of New York's Subway system. It was noted in several articles publish by the New York Times that the Subway system has issues regarding delays. Of these issues the top three causes were listed as Overcrowding, Track maintenance and Signal Failures or other

track related issues[20]. Of these issues it should be noted that Overcrowding made up around 30,000 incidents within a given month, and as stayed consistently around that number going forward into 2017. This number was based the “dwell time” or time in which the car stays at the station during loading and unloading of passengers, where any time over 5 minutes of dwell was marked as a delay. From 1990 to 2015 the number of riders on the subways as increase from 1 billion to 1.8 billion, which as lead to delay, however the number of cars has not increased leading to a logistical nightmare. From 2007 to 2017 delays have also lead to most lines preforming anywhere from 22 to 60 percent on time. This was troubling since most riders in the event of an evacuation would be delayed not by an inability to find a way to leave, but from their method being unable to evacuate in a timely manner.

There is also the matter of their only being 6 lines that have the potential to allow citizens to leave Manhattan altogether, with those being on the lower percentage of on-time performance. While this may not seem like a big issue, as delays are common in any high volume mass transit, it become more apparent when evaluating how late these trains can be. Data suggest that within an hour a line can fall behind by 6 train cars per day[23] for those relying on an exit from an at-risk area, or even leaving the city all together not having a reliable exit strategy can be the difference between life and death. And the subway system does not have the ability to make up these missed cars; once at the end of a day this can mean that certain cars never ran meaning less people can be moved than was planned. The cars on the New York subway can hold up to 200 occupants, with 8 to 11 cars being on a train

[20] Fitzsimmons, Emma G., Ford Fessenden, and K. K. Rebecca. "Every New York City Subway Line Is Getting Worse. Here's Why." The New York Times. June 28, 2017. Accessed December 22, 2018. https://www.nytimes.com/interactive/2017/06/28/nyregion/subway-delays-overcrowding.html.
[23] Fessenden, Ford, Emma G. Fitzsimmons, and K. K. Rebecca. "New York's Subways Are Not Just Delayed. Some Trains Don't Run at All." The New York Times. August 07, 2017. Accessed December 22, 2018. https://www.nytimes.com/interactive/2017/08/07/nyregion/new-yorks-subways-are-not-justdelayed-some-trains-dont-run-at-all.html.

meaning that anywhere from 9,600 to 13,200 people could have lost their ability to move across or away from the city.

If we also factor in situations where the railways are not traversable, those being situations such as failures on the line or needed repairs, which were noted as being around 10,000 in 2017, this becomes an even larger issue as these types of failures can cause the line from being usable. In this situation citizen will need to find alternate methods of leaving. If people need to leave Manhattan, there are only a few other options that allow you to leave via railway. Metro North, Amtrak and NJ Transit are all methods that allow for people to leave Manhattan, however there are only 6 stations which can access these lines.

Evacuation of Injured and Disabled

For those who are uncapable of evacuating from the city of their own power the city provides a service to move people from their homes to evacuation points. This comes in the form of ambulances; citizens can call 911 and request that they be moved to which someone will come and pick the person up and move them. However, original criticism of this process came in the form of the evaluation of the traffic issue brought up earlier. During evacuation streets will most likely be dealing with traffic, causing it to be difficult to move people across the city. While emergency services would be able to move much more smoothly there would still be the issue of the viability of moving each person individually from their home to the shelter. This also brings into question of how many ambulances are used in this process and how many are devoted to moving those in medical facilities to shelters or other hospitals during an evacuation as well as if shelters can provide for those evacuated.

Chapter 3: Understanding Precedence in Natural Disaster

Importance of Precedents Disasters

Before the designing of the shelter, an analysis of how a natural disaster can affect a certain region needs to take place. It is important to understand what issues need to be mitigated. By looking at other disasters like those for the site designers can understand what factors they need to be prepared for. For this argument two precedence were chosen to better understand what this shelter will needs to react to. Since the site that will be New York City, however for future designer's precedence should be selected based on what the most likely threats to the site might be. In the case of New York, a survey by FEMA sought to show the risk associated with the state. The result of said survey was shown to be susceptible to flooding, frost and extreme cold, Hurricanes and Earthquakes[21]. Of these the threats were inly in moderate levels, except for freezing and flooding, the former being something the state deals with regularly. There was also with earthquakes and hurricanes we in that New York was already prepared to defend against the former via building codes, while the latter was only dealt with in a planning phase. It was also possible that hurricanes could be the cause of said flooding via a storm surge, a natural disaster that is caused by displacement of sea water via a hurricane.

[21] United States. Federal Emergency Management Agency. 1990. Risks and Hazards : A State by State Guide. Washington, D.C: Federal Emergency Management Agency.

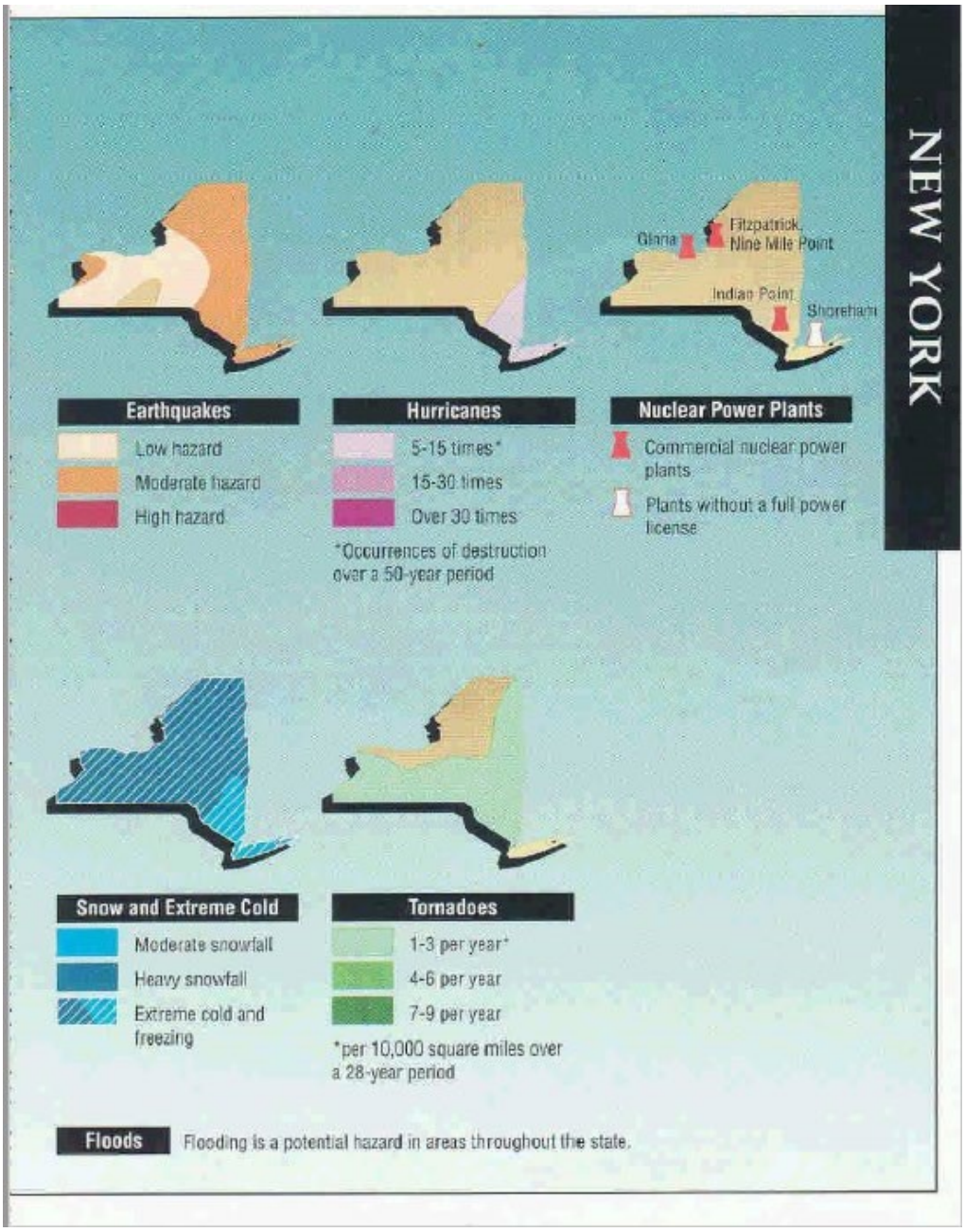

Figure 17: Natural Disasters by State (Source: FEMA)

To continue investigation of these threats Hurricane Katrina and Hurricane

Sandy were studied, the former being an example of a worst-case scenario and the latter being an example of how flooding could and would affect New York City in the case of a flood via hurricane.

Hurricane Katrina and New Orleans

In studying Hurricane Katrina for how it became the second most destructive hurricane in US history it became apparent that the focus of the research needed to be on the area most effected; that being New Orleans. Of the 1,800 who died in the storms wake, 1,500[22] occurred in the state of Louisiana, with the largest concentration occurring on New Orleans. This was due to the massive failure in the city's levee system which allowed flood waters to reach into the unprepared streets.

- ALABAMA 2
- FLORIDA 14
- GEORGIA 2
- KENTUCKY 1
- LOUISIANA 986–1,577 (INCLUDES OUT-OF-STATE EVACUEES COUNTED BY LOUISIANA)
- MISSISSIPPI 238
- OHIO 2
- **TOTAL** **1,245–1,836**

The city of New Orleans was developed originally as a port settlement by the French to control trade in the Gulf region of North America. Not only was the land the city was developed on in a coastal area, allowing it to be much more accessible to ships, but it also was at the main entry point to the Mississippi river. This river extends far into the United states along a North-South axis allowing the French the

[22] John L. Beven II; Lixion A Avila; Eric S. Blake; Daniel P. Brown; James L. Franklin; Richard D. Knabb; Richard J. Pasch; Jamie R. Rhome; Stacy R. Stewart (March 2008). "Annual Summary: Atlantic Hurricane Season of 2005" (PDF). Monthly Weather Review. Miami, Florida: American Meteorological Society. 136 (3): 1131–1141. Bibcode:2008MWRv..136.1109B. doi:10.1175/2007MWR2074.1. Retrieved July 6, 2014.

opportunity to move trade within the future US as well as allowed for them to easily expand into those areas in the future. However, the land in the New Orleans area had a topography that made it susceptible to flooding. There were large pockets of land where the land dipped below sea level which allowed for flood waters to pool. The settlers selected the original location for the port city along the highest point of the land, which was along the river itself. This was due to build-up in sediment deposited from the running river, creating a natural levee protecting the city from flooding.

Skipping ahead to the 19th century major changes in the population of New Orleans would change how the city developed. The Hattian revolution, along with the freeing of the slaves would lead to substantial amounts of citizens who would call New Orleans home and as they created new families housing was needed for future populace. What this meant for the city was that it needed to extend its city grid into those low-laying pockets which were known historically to be large issues in terms of flooding. A study by MIT wrote that "Louisiana was hit by 49 of the 273 hurricanes that made landfall on the American Atlantic Coast between 1851 and 2004. In addition, eighteen of the ninety-two major hurricanes with Saffir-Simpson ratings of category 3 or above have struck the state (U.S. mainland hurricane strikes by state, 1851-2004)."[23] At this point historically, New Orleans had dealt with over 9 cases of hurricanes and multiple cases of flooding or close calls, however mitigation efforts had been installed around the city in the form of levees and pump stations which would act as a barrier against the flood waters and then pump away the excess water.

[23] McCarragher, Barbara. "Hurricanes: History." Maritime Theater. Accessed December 22, 2018. http://web.mit.edu/12.000/www/m2010/teams/neworleans1/hurricane history.htm.

This method was not without fault however as a misinterpretation of the design codes The Army Corps of Engineers.

In 2005 Hurricane Katrina hit the city of New Orleans. By the time the storm hit the city it had gone from a category 5 hurricane to a category 3. Reports suggest that the levee system should have been able capable of holding back the flood waters of such a hurricane, in fact it was planned that it would do so, however the levee system still failed. This was due to improper construction of the levee system; due to a misinterpretation of how deep the levees needed to reach down into the earth flood water was able to seep beneath the wall and weaken the base, causing the walls to fail and successively overpower the others. In her research of this matter, Hassan Mashriqui said the following about why the levees failed:

> "Storm surge pushing across shallow Lake Borgne from the east is constrained by these MRGO levees to the south and, to the north, by the long-standing levees of the Intracoastal Waterway (GIWW). Initially ten or more miles apart, these two channels meet, and when they do, the water building between their levees is squeezed into a single channel – the Funnel – only 260 yards wide, constrained by levees 14 feet to 16 feet high…. In concert with the denuded marshes, it could increase the local storm surge hitting the Intracoastal Waterway by 20 percent to 40 percent – a critical and fundamental flaw."[24]

[24] Heerden, Ivor van; Bryan, Mike (May 18, 2006). "The Storm: What Went Wrong and Why During Hurricane Katrina—the Inside Story from One Louisiana Scientist". Penguin – via Google Books.

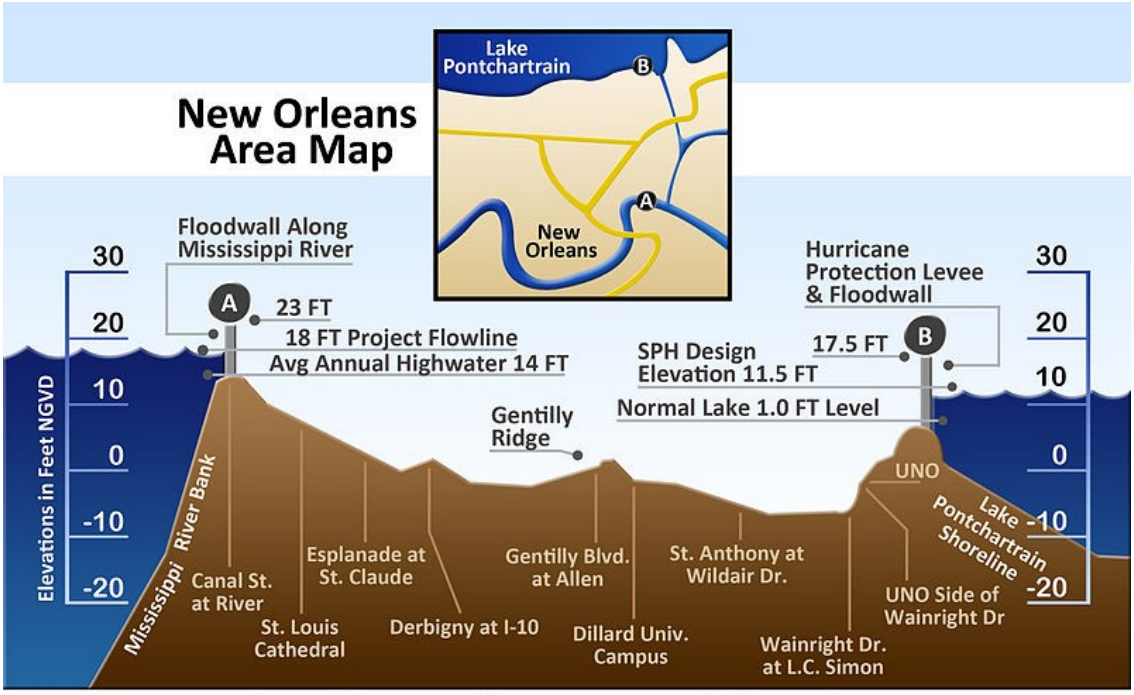

Figure 18: Section through New Orleans (Source: WikiMedia)

Because the contours of the land dipped down into a bowl-shape past the levee system the floodwater was drawn into the heavily populated areas of New Orleans, causing massive amount of damage and death. Those who were able to escape were sent to areas of last refuge, such as the football stadium, and were forced to wait there until help could arrive. Those less fortunate either sought out higher places to wait, such as the highways, or tried to scavenge in the flooded areas or on top of homes.

Help was not an immediate as the unexpected failure of the levee system lead to confusion, and in turn slowed the response of FEMA and the Red Cross. One of the key issues sighted by the response of efforts after Katrina was that communication

was slow and ineffective.[25] Government agencies and people on the ground had difficulty communicated and coordinating logistics which led to a delayed response.

Katrina acts as a cautionary tale for those who believe that planning for a worst-case scenario is a foolish endeavor. New Orleans was a city that knew it was susceptible to flooding and hurricanes and so prepared to defend against those factors. However, it only took one failure, one that took place in defense strategy, that lead to such a massive loss in life. If is for situations like these that this thesis was developed, so that in case these protection plans fail people have a last line of defense.

This precedent also highlights the importance of having a set plan in place for these situations. What was seen with Katrina was that a lack of a prepared plan for a failure of the levee system lead to a delayed reaction from those who attempted to give aid. Not only that, those who were affected by the storm did not know where they were to evacuate to as the information was not communicated clearly. What this meant for the thesis was that the future documents were that the design of the final product needed to consider the concept of how the facility communicated with the people effected as well as with those organizing relief efforts.

Hurricane Sandy and New York

Studying Hurricane Katrina was useful for understanding what can happen in a worst-case scenario and why having a shelter is important, but for this thesis a

[25] Gheytanchi A, Joseph L, Gierlach E, Kimpara S, Housley J, Franco ZE, and Beutler LE. 2007. "The Dirty Dozen: Twelve Failures of the Hurricane Katrina Response and How Psychology Can Help." The American Psychologist 62 (2): 118–30.

baseline was needed to understand what sort of damage could be expected from a possible natural disaster. Since for this thesis the scenario took place in New York research was done on Hurricane Sandy and its effects on New York as a baseline for what could be expected in a natural disaster. For any future projects it is imperative that designers find precedents like the geological and environmental factors to their site.

In 2012 a category 3 Hurricane Sandy developed in the western Caribbean Sea causing massive amounts of damage along multiple regions in the East of the Americas, with a total of 24 states in the US effected. Of those effected New Jersey and New York saw damages that followed a specific path that helped to inform where future damages would happen. While Hurricane Sandy did not make landfall on New York proper, secondary effects in the form of a storm surge caused a large volume of water to be forced towards the east coast, leading to massive amount of flooding. This, accompanied with a 20% increase in the tides due to a full moon created a situation in which the storm surge would have a much large reaching and destructive force when following the rivers into New York City. As the water headed towards the Lower Bay large amount of Brooklyn's southern coast became inundated with floodwater from the initial impact. The shockwave continued into the New York Harbor, where large volumes of high velocity water was forced into The Narrows, and then spread out into the Upper Bay. The floodwater had a large effect on New Jersey's low-lying port areas while the rest of the destructive force was concentrated on Lower Manhattan, flooding areas such as Battery Park, Wall Street and the 9/11 memorial area. Finally, the last bits of the floodwaters broke off and followed either

the East River or the Hudson River, where the lower lying areas along Manhattan saw small amount of flooding that was less impactful in comparison to the original surge effects.

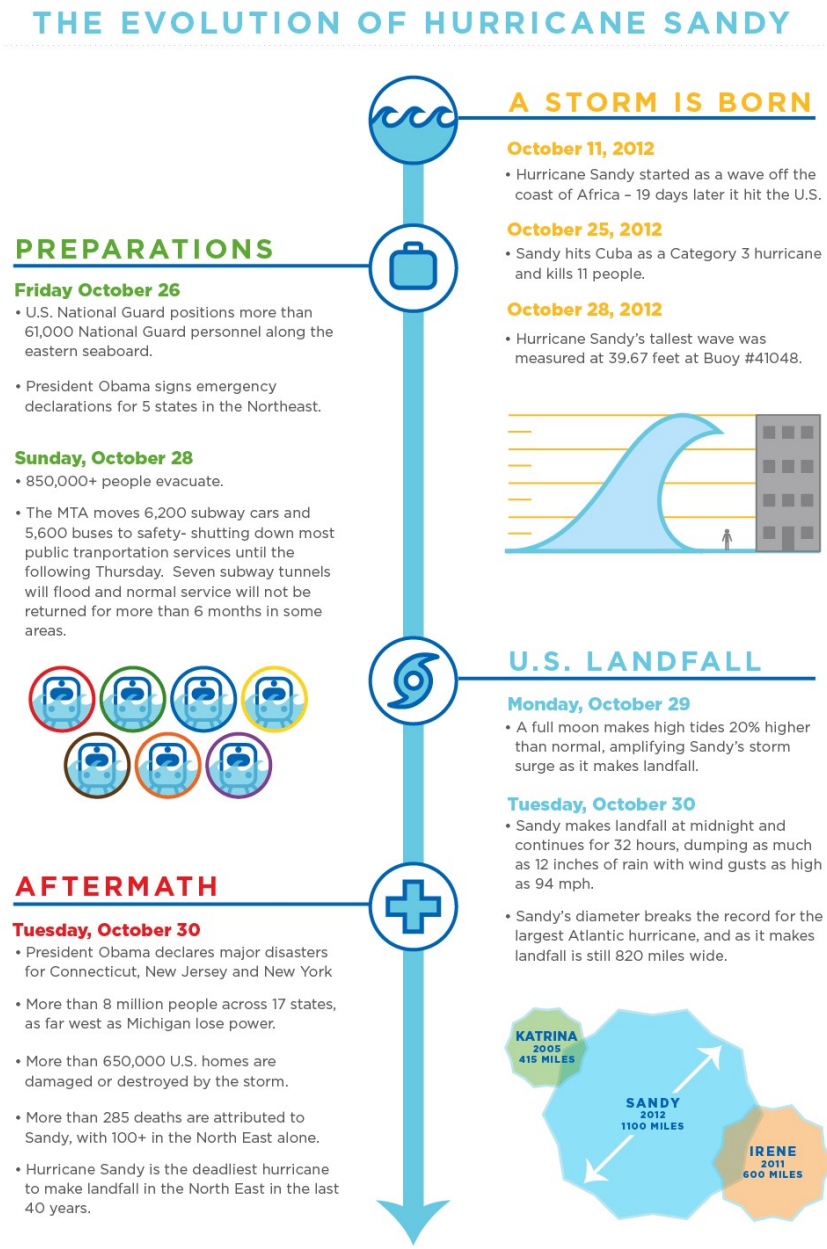

Figure 19: Timeline of Hurricane Sandy (Source: Charity Sub)[26]

[26] "HURRICANE SANDY RECOVERY." Hurricane Sandy – March 2013 – CharitySub. Accessed December 15, 2017. https://www.charitysub.org/hurricane-sandy/.

After the damage was accessed Sandy became known as the third most costly hurricane in the US Atlantic, coming in behind Hurricane Katrina and Harvey. While not as impactful in terms of death, which were not insubstantial as 157 of the total 233 deaths were in the US, Sandy had a large amount of property damage which left substantial amounts of people displaced as well as multiple issues with flooded infrastructure elements. In preparation for the storm over 850,000 people were evacuated from New York over a 2-day period. On October 28, one day before the storm hit, subway lines were shut down in preparation for the flooding, however when the surge finally hit Manhattan seven subway lines were flooded. These lines were not restored to full functioning status for around 6 months. There was also an issue with power in Manhattan after the storm hit as two substations exploded, leaving many of the homes and facilities without power. Along with this NYU Langone Medical Center lost power leading to a mass evacuation of patients deeper into the unaffected cities.

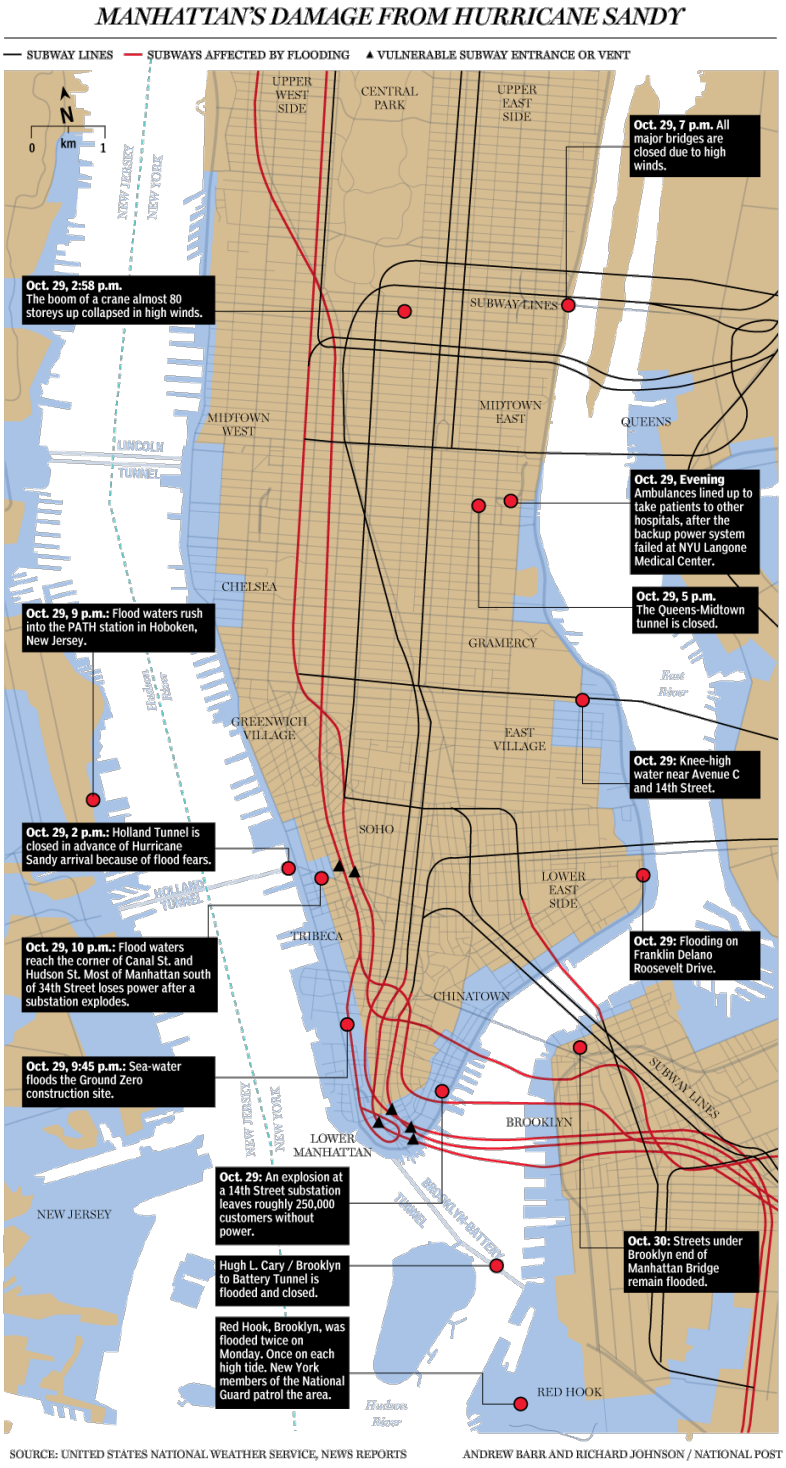

Figure 20: Damage of Hurricane Sandy (Source: National Post)[27]

[27] Barr, Andrew. "Manhattans Damage from Hurricane Sandy." National Post. Accessed December 22, 2018. http://nationalpost.com/author/andrew-barr.

In understanding Sandy's aftermath there were some clear lessons in which could be taken away. The first of which was the path of travel of a storm surge. While Sandy was destructive it acts it did show where the surges would go first, as well as what areas are susceptible to flooding.

Chapter 4: Precedents for Program

Selection Precedents

To build a program for the shelter there were considerations into what types of precedents would be needed. In general, the shelter protype would need two different programs, one of a shelter and one of a community center. There would also need to be consideration for principles of design that could help with organization of spaces as well as optimizing how space is used. These would be precedence for Program and precedence for Design.

Micro Housing and Dorm Spaces

One type of precedent that that is beneficial to understanding and optimizing space at was Micro Housing. In today's market many apartments have begun to shrink their spaces to accommodate more people into one lot. Year after year apartments have shrunk in their floor area[28]. Currently a New Manhattan apartment studio apartment in average us 692 sq. ft while a single bedroom is 671 sq. ft [32] Micro housing acts to

[28] Plitt, Amy. "NYC Apartments Are Shrinking, but Not as Much as Other Cities." Curbed NY. September 21, 2016. Accessed December 22, 2018. https://ny.curbed.com/2016/9/21/12999536/nycapartment-sizes-decrease.

get “the most bang for your buck” by giving users multiple uses for each room in the apartment.

However, for the purpose of the shelter micro housing provides another use than to provide permeant housing. It also acts as a method to provides small transforming spaces for dormitories during a disaster.

In architect Gary Chang’s Domestic Transformer, he uses this principle of micro housing to optimize his 345 square foot apartment for multiple uses. In Hong Kong many apartments do not have the luxury of having large spaces, especially with the density of the city’s population. Domestic Transformer seems to have a similar problem; however, Chang was able to provide multiple spaces within the small footprint by insetting programs into the walls.

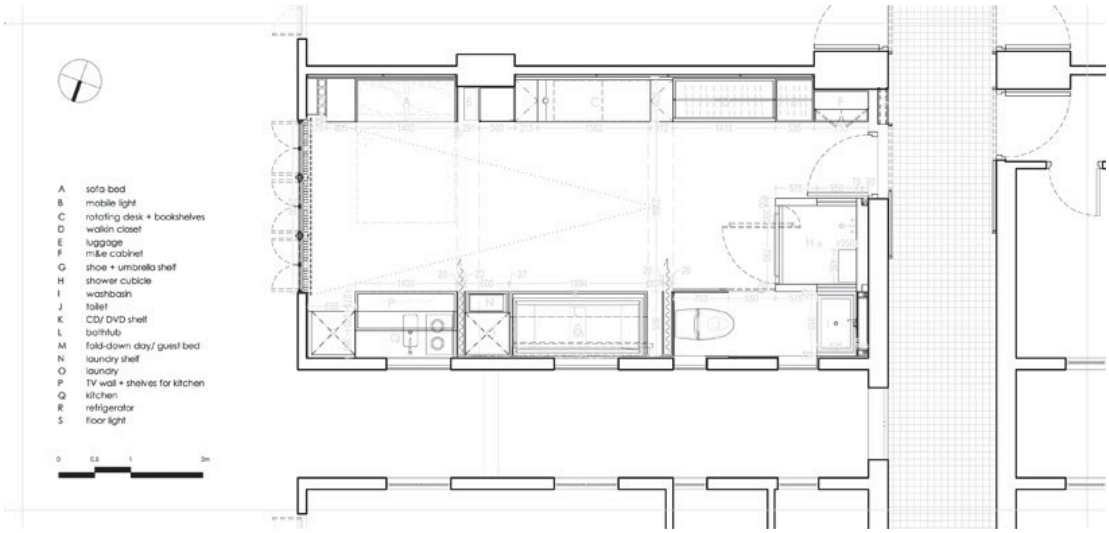

Figure 21. Domestic Transformer (source: Archdaily)

[32] "Manhattan, NY Rental Market Trends." Apartments for Rent – RENTCafé. Accessed December 22, 2018. https://www.rentcafe.com/average-rent-market-trends/us/ny/manhattan/./

The central space of Domestic Transformer acts as the ‘active’ space for the apartment. As the user’s needs different elements, such as a bedroom, a kitchen or even a library all the user needs to do is move a wall element to reveal what they need. While it might be difficult to implements such a method for micro housing in the US, for this project it is useful for creating transformative spaces for disaster sheltering. To scale the design up, having beds or other facilities that are easily accessible by those looking for shelter during a disaster would help to greatly decrease the time it would take to set up a shelter, or help to modulate spaces for different family sizes.

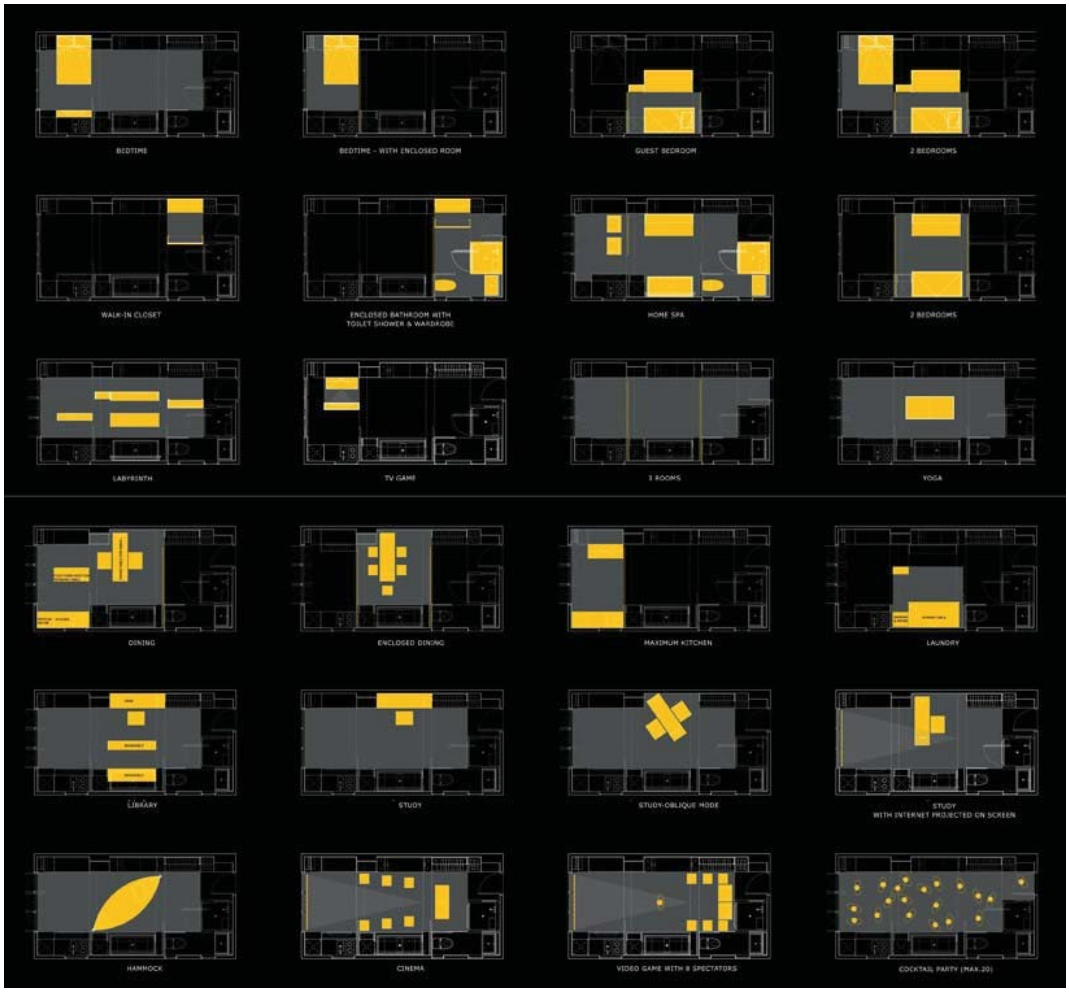

Figure 22. Domestic Transformer configurations (source: Archdaily)

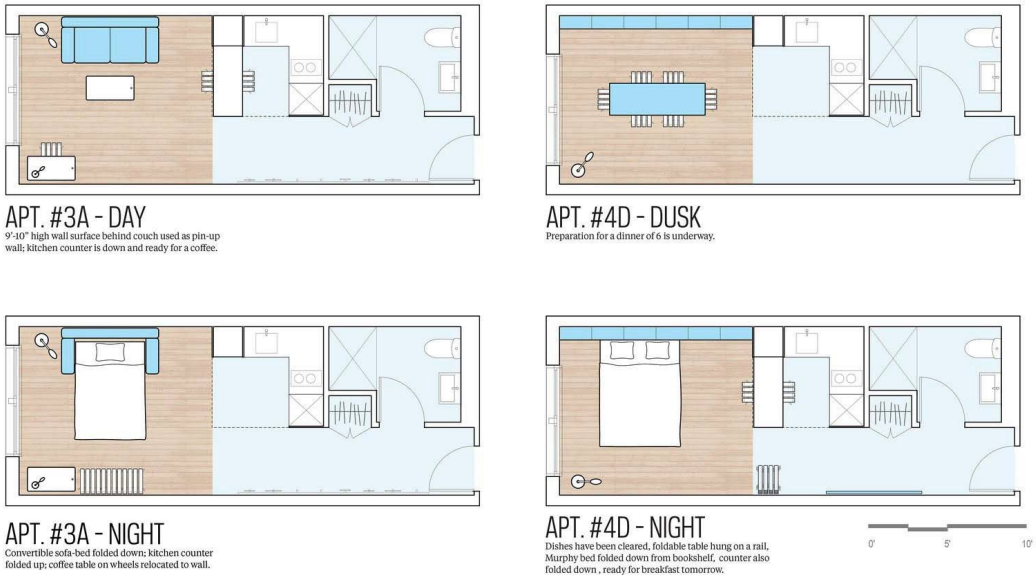

Figure 23. My Micro NY (source: Archdaily)

In a similar vein, nARCHITECTS project, My Micro NY provides another approach to micro housing, that being to slice the program into two uses. My Micro NY uses a space of 250 sq. ft. and breaks down what a person needs into two uses; the space for utilities and the space for the user. These two spaces are known as the Toolbox, which are spaces such as the bathroom, kitchen and storage, and the Canvas, which is the bedroom and living room space. The Toolbox acts as an extremely optimized space that provides all the basic amenities of life in a compact space. It is a rigid form that does not change its use or physical form throughout the life of the apartment. The Canvas however is a much more dynamic and fluid space that is building to allow the user to express their life style. It is an open room with a sofa couch that changes its form depending on the needs of the end user.

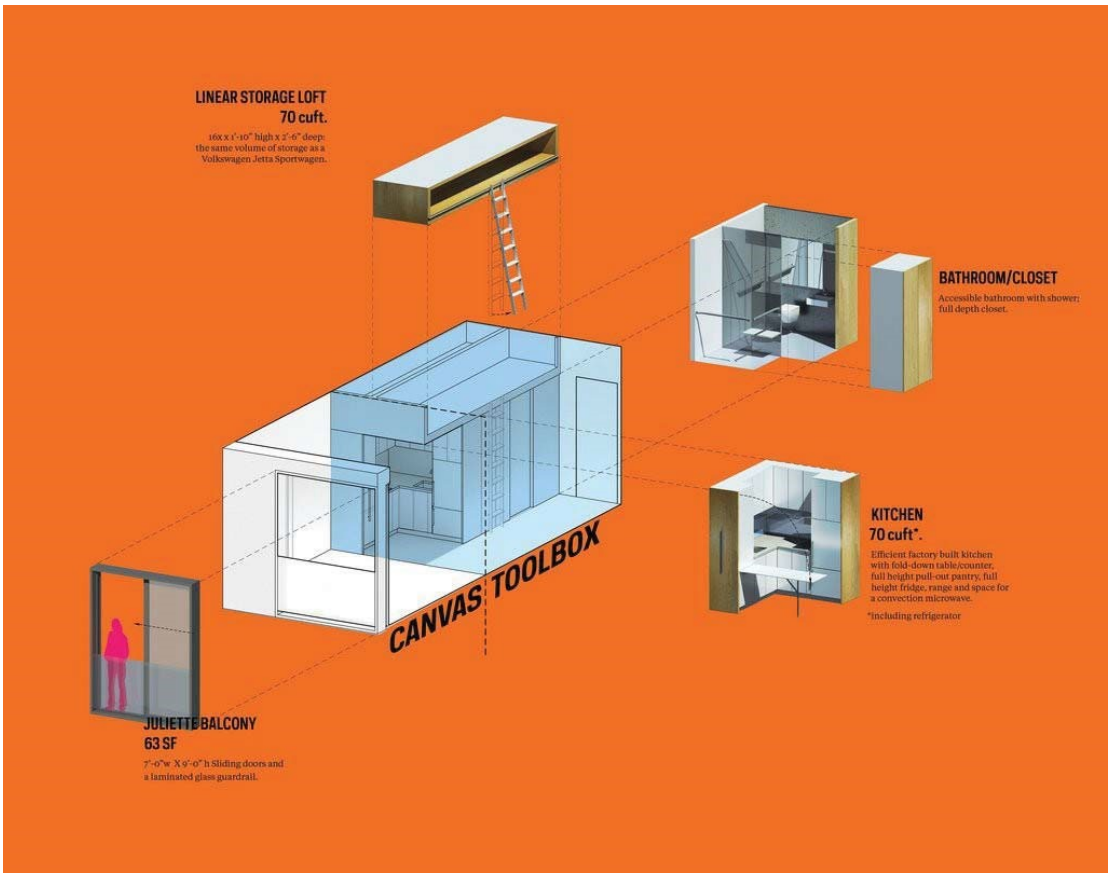

Figure 24. My Micro NY Canvas and Toolbox (source: Archdaily)

Taking this concept and scaling it up much like the Chang's apartment shelters could use a similar design philosophy. By having ridged spaces that provide uses for the shelter, such as a shower space, bathrooms, a kitchen space this can inform the placement of where the shelter spaces can be. Creating a mailable program that is surrounded by or centered on the Ridged use spaces would allow the community using the shelter to develop the program of the shelter into whatever they need at the time of the disaster.

Both programs also bring up an important issue of what is needed to really give someone a personal space. By providing users the ability to carve out a space that is all their own and manipulating the spaces in a way that feels personal both

apartments allow users to become invested in their spaces and their homes. While there are a limited number of configurations the architects both allow the users to dictate what their home will look like.

Taking this principle into consideration when designing the shelter, one of the critiques of modern disaster shelters how open and impersonal it all is. People are given gurneys or tents, but they really have no way to make the space theirs. By providing something similar to the micro housing examples it would not only allow those using the shelter to feel more at home, it would also be operating the shelter the ability to develop the spaces to what the population needs, such as large spaces for families, or to set certain areas for males vs females.

Community Spaces

With the Community Center being the public face of the Shelter, it would be imperative that the spaces were both useful for the community while also being large enough to be converted into dorm spaces. Research was done into many types of uses but only ones that could help this specific community. In general, there needed to be some spaces that could be used by both children and adults, one such space being recreational spaces such as a gym space. In general, such spaces have a large amount of open floor space, with a general size being around 60’ x 100’ for a high school regulation court. Having at least one large scale space such as this would provide a fair bit of room for dormitory space. It also provides the reason to include showers. A shower room with lockers for both men and women to use would be

useful for the community to use for working out but would also provide bathing facilities for the community during a disaster.

Figure 25. Can Clariana Exterior (source: Archdaily)

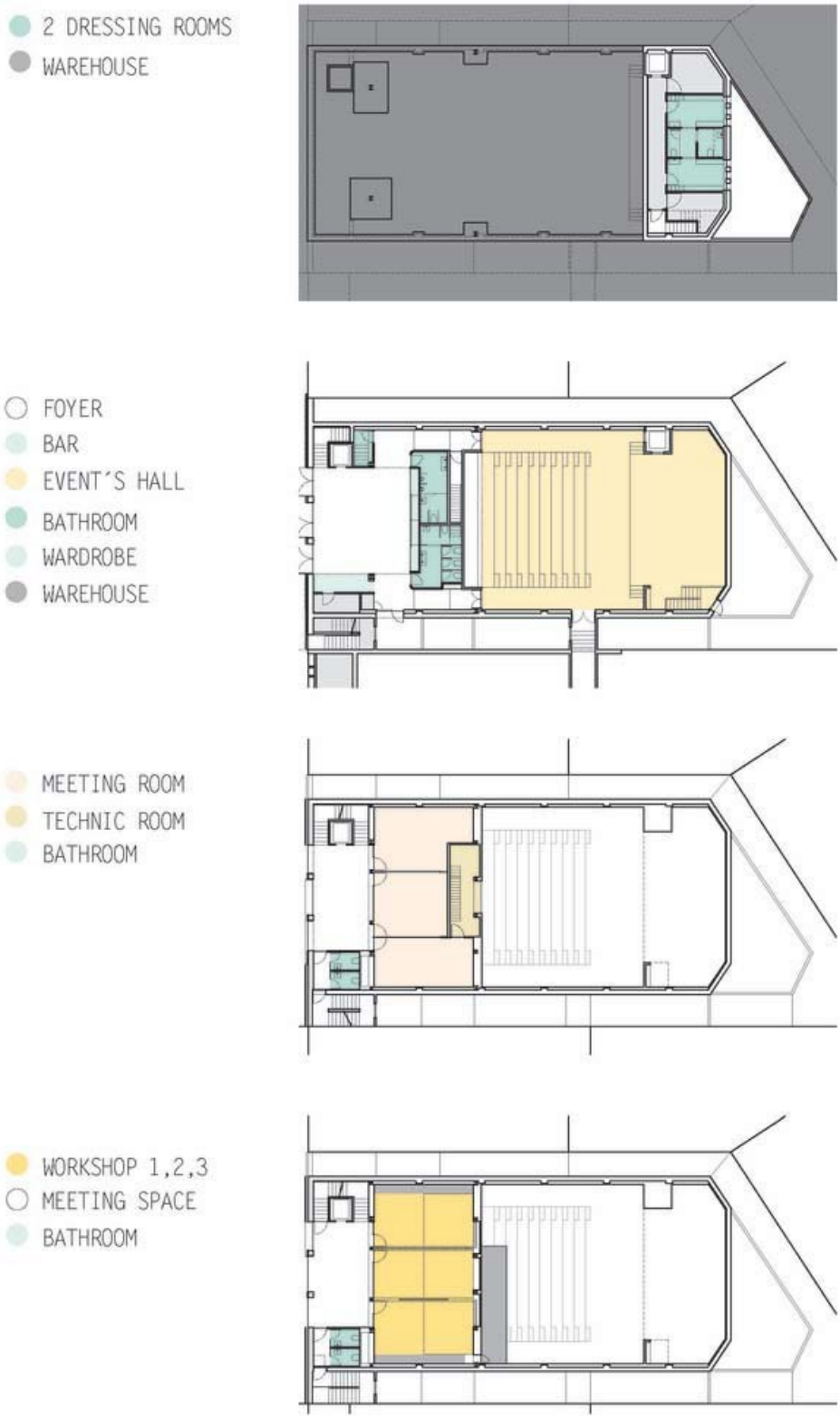

Figure 26. Floorplans of Can Clariana (source: Archdaily)

Other such spaces that would do well with this type of community center program would be that of an auditorium or theatre space. For a community such a space could be used for announcements, town halls or even performances for local or visiting performers or lecturers. While not as open as a gym such a space is quite larger in scale and could provide a reasonable amount of space for a dormitory space. Looking at spaces such as the Can Clariana Cultural Civic Center in Barcelona it can be seen how a smaller scale version of an auditorium space could be fit into the footprint of a smaller building. By adapting a similar method to build smaller auditoriums spaces it would allow the users of the space to be able to provide a medium size dorm space during a disaster.

Finally, one other type of space that is useful to the community would be learning spaces such as classrooms and maker spaces. Spaces such as these could provide the community with spaces to learn new skills or teach things to others. For a disaster this would also provide a secondary service by providing a space to learn how to prepare for a disaster or supply tools for using during a reconstruction effort.

In most cases such a facility could be a ridged program, however a project, however Beaver Works in Cambridge, provides a way to develop a more fluid maker and learning space. Like the domestic transformer Beaver Works has walls that can move to adjust the spaces within it. A conference room could become two seminar rooms, or a medium sized classroom just be adjusting where the walls are. Applying this method of dividing room into smaller classroom spaces would be invaluable to creating dormitory spaces during a disaster.

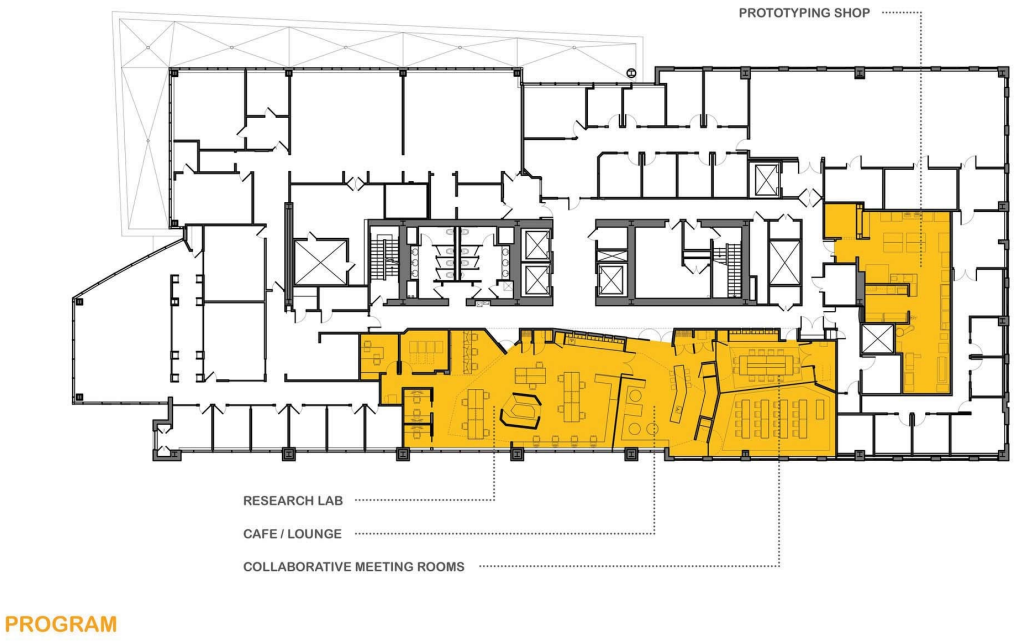

Figure 27. Beaver Works Floorplan (source: Archdaily)

With the Maker spaces, for larger spaces there would need to be some sort of ridged room that could be used for larger scale equipment, however as for workshop space it is simple to assign a larger scale space as such and provide easily movable furniture for users to augment the room in whatever way they would like.

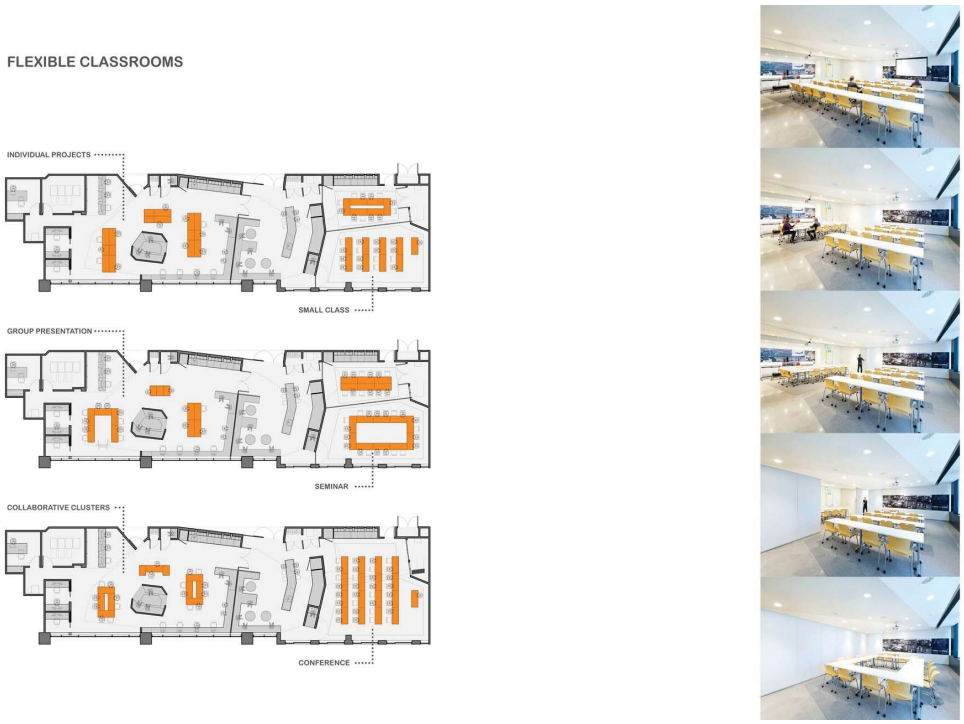

Figure 28. Beaver Works Classroom Configurations (source: Archdaily)

CALPSO Homeless Service Center

The most important precedent to creating the program of the shelter had to be a shelter itself. To fully understands what spaces were needed a homeless shelter was studied to find a general design considerations and organizational elements. To this end a project designed for San Luis Obispo in California called the CAPSLO Homeless Services Center was selected. This design was a part of a design competition for the city in which the center needed to blend both housing and service into one location, while also allowing for 2- hour efficiency in operation within the design.

Figure 29: CALPSO proposed Exterior (source: Archdaily)

In a general sense the building uses organization of their spaces as well as grouping of similar functions to play a key role in defining use and access. CAPSLO can be divided vertically into two classifications; Public services spaces on the first floor and private housing spaces on the second floor. The ground floor contains spaces such as the clinic for medical services, dining area for occupants and general life services such as showers and lounge. However, these spaces have their own organization along the East-West axis that informs the openness versus the intimacy of these spaces. On the western end, near the entrance to the space we find the most widespread use spaces. These include the kitchen and dining space as well as community room. For those currently using the space it becomes a simple walk from the door to spaces that are for the community and does not interrupt the circulation. This is the simpler of the two sides as the Eastern end becomes more intimate for those who are in need of medical attention or counseling. The first stages of spaces

heading east are still community spaces however these are considered more secure spaces. Users need to pass first by the reception and then the main office to enter this space which creates a checkpoint and in turn a sense of formality and security to these spaces. As you walk past, the hallway creates and atmosphere of intimacy as you are coming from a much larger series of room into smaller and closer office-sized rooms. The first few spaces that are open are services for the residents; lockers for personal items, a mail room, showers and laundry are protected from those who just walk into the shelter. As the user walks past this phase the user finds the medical consulting wing. These spaces are where those such as pregnant mothers or those with medical conditions can walk in for free consultation. Here those coming in can feel safe that they are away from the more public areas and can have a more open dialogue without giving up their privacy.

Figure 30. CALPSO Floorplan (source: Archdaily)

There are pros and cons to this organization that came to mind when analyzing the first floor. The east-west organizing spine to the facility is simple and made sense

to the design, however the western end makes more sense than the eastern. It could be argued that having pass by the lounge and showers to reach the medical wing detracts from the intimacy that the spaces tried to achieve, as well as creates a situation where you need to walk past the reception from the second floor on the way to your morning shower. However, in concept the design is smart by defining zones and using the reception as a security element to those private spaces. When adapting this organization thought needed to be put into alternative entrances into the private zones to preserve dignity and how to best protect those spaces without isolating them.

The second floor, the more signal use of the floors, is entirely devoted to dormitories. The areas are broken into three clear areas; Single males in the western end, single females in the eastern end with families within the center core. General division by gender made sense for this design, however there is an interesting implication to the space when looking at the fourth special type that was included in the second floor. A security office was included overtop of where on the first floor its counterpart would be placed. While this made sense it also creates an implication that the male dorms need to be monitored more that the female side, which could be a valid claim, but for the sake of the thesis would needed to be considered when organizing similar spaces. Having the private rooms on the second floor for this project was a understandable design choice as it meant that only the stairs to get to the second floor would need to be guarded and residence would have an entire floor to feel as though they are at home and a part of a private community. It also maximized the amount of dorm spaces while not sacrificing room to the service spaces that are located on the second floor. As was also discussed the question of implication of which areas need to be

monitored over others is important, however the need for security cannot be sacrificed in these spaces. Much like with this thesis the concept of incidents occurring was to be considered in the spaces and it would be ignorant not to have a way to prevent incidents in the shelter.

Along with the special origination the program itself lent insight into what types of spaces needed to be considered in designing the space. These can be divided into three grouping that can be subdivided further; those being Administration and Security, Residential and Community, and Service. Administrative and security spaces were imperative when going forward with this thesis as how the facility is maintained is just as important as what is within it. Spaces such as reception and offices for those operating the facility can both provide staging rooms for the disaster shelter as well as could provide an implied security to the spaces by proximity allowing for those near them to feel safer.

Residential and Community Spaces such as the dining room and dorms were also going to be important going forward as they would make up the bulk of the shelter. These spaces could be subdivided into Public and Private spaces. 50% of CALPSO was private dorm space, but this was based on the project being only 2 stories, however figuring out how much space is devoted to non-dorm space in the final design was going to be important to maximizing how much special efficiency. Their also needs to be a straightforward way to divide spaces based on gender and family size. Whether this meant there was a clear architectural division or if there was a flexible way to change the amount of space divided up would be important to how space is defined as well as how they are secured. The other subdivision, public

spaces, are rooms like the dining room or the lounge. These were spaces that provided users with a community experiences and were relaxing and open. These would become necessary to the design of the disaster shelter as they would allow for users to communicate and share their experiences and feel at home, however there is an argument to how much space should be given to these spaces. Because they are so open and big a balancing how much is given to these spaces and is imperative as too many large spaces will eat into the square footage of the project.

Finally, service spaces play a crucial role in the functionality of the project. Services can be broken into daily life spaces like shower rooms and kitchen, medical spaces, and luxury spaces such as lockers and the mail room. Life spaces were a necessary consideration to providing for all those who were going to be displaced from a natural disaster. However, some of those spaces are difficult to plan for when developing a facility as when the shelter is not used it must serve a secondary function, so those rooms need to be used in either design or be easily convertible. For instance, a bathroom is needed in any facility, however a kitchen means that the space needs to have either a culinary aspect to it or it needs to have an area that can be converted to one in times of need. Medical spaces are also tricky as unlike CALPSO the disaster shelter will most likely be a temporary area that will be used less and less as occupants began to reach a state of recovery but allocating where and how much space will be temporary medical facilities will be dependent to the extent of the disaster. This also brought up the consideration of to what extent of service will be provided; will it be consultation a quick medical response or will this space be able to accommodate those who need immediate medical assistance or at least be able to

stabilize them until help can come evacuate them. The luxury rooms are spaces that provide users will less than necessary services such as internet and phone lines, or storage for personal affects. The reason that these are designated as luxuries as these services are not necessary to survival, but can help to comfort the users within the shelter allowing them to feel more at home. These rooms could also be phases out of the design or organization if more immediate room is needed. What rooms were selected as well as how to make them flexible would be a challenge as the argument for the inclusion of each over other types would need to be made when defending the thesis.

Final Program Breakdown

After going through the programs of multiple facilities a program was generated. This layout provides a small summary of the programmatic elements that will be used when going through the design phase of this project. The Program is broken into 5 Sections; Commercial, Gym, Community, Learning and General Use. Each type of space within it is provided with its potential conversion in a disaster scenario giving a rough idea of how a space could potentially look once it is converted.

	Name	Area (sq ft)	Height	Quantity	Final Total	Shelter Conversion Spaces
COMMERCIAL	Restaurant	4250	15'	1	4250	Food Preperation Area Medical Treatment Area
	Pharmacy	4250	15'	1	4250	
GENERAL SERVICES	Administration	1000	10'	1	1000	Logtistic Center Service
	Service Spaces	2500	varies	9	22500	

	Lobby	800	15'	1	800	Lobby
	Daycare space	2750	10'	1	2750	Daycare Space
GYM	Basketball Court	8000	20'	2	16000	Temporary Dorm Space
	Locker Room/Showers	9775	10'	1	9775	Shower and Laundry
	Gym	3000	10'	1	3000	Temporary Dorm Space
COMMUNITY SPACES	Auditorium/ Theatre	3500	15'	1	3500	Temporary Dorm Space
	Auditorium/ Theatre	6000	15'	1	6000	Temporary Dorm Space
	Open Spaces	3487.5	10'	1	3487.5	Relaxation Space
	Public Exhibition Space	1662.5	10'	1	1662.5	Temporary Dorm Space
	Public Use Space	5812.5	10'	1	5812.5	Temporary Dorm Space
LEARNING	Small Library	7500	10'	1	7500	Temporary Dorm Space
	Media Room	7500	10'	1	7500	Communication Area
	Study space	5725	10'	2	11450	Dorm Space
	Maker Spaces	9100	10'	1	9100	Self-Service Area
	Classroom	500	10'	8	4000	Family Dorm
					124337.5	

Figure 31: Program Break down with Conversions (Source: Zain Shah)

General Spaces

These spaces are rooms that provide general functions for the Shelter. Spaces such as Mechanical space and Storage Space fall under this category. Taking a page

from the precedents, these spaces will become the shelter's core, providing a table point for design and for the program to rotate around.

Commercial Spaces

Many multi-use buildings have a first floor commercial factor. Many of the buildings surrounding the site for the shelter have a similar situation, so providing similar would not be uncalled for. In this shelter the commercial element will provide a source of revenue to help fund the community aspects of the facility. To add to its use, these spaces could provide much needed services for the shelter. If the store renting the space is a restaurant, it could help provide meals and cooking services. If it is a pharmacy it could help provide medication for those who need it.

Gym Spaces

Gym space would provide one of the main draws for the facility. Spaces such as a workout room and basketball court provide large, usable space that can be enjoyed by anyone. When not functioning as a shelter these spaces could then be converted into large dorm spaces, along with the showers and locker room being bathing facilities for those who no longer have a home.

Learning Spaces

Learning Spaces provide quite areas for people to read books, study or hold meetings. These medium to small spaces would provide a more focused use in comparison to all other spaces but would be useful in that they would provide modular spaces that could be converted into dorms. One other aspect is that these

rooms would provide services that could be used by the community in a crisis. A Media room could provide internet access to help communicate with those far away or make insurance claims, a library could provide a space to relax and pass time reading and a makerspace could loan tools for individuals to use in their own repairs or to build small things that are needed at the time.

Community Spaces

Community spaces provide a way to engage the local population. These spaces could be used for things such as town halls, performances, cultural events or even art shows. It is the space the community itself helps to design and coordinate to make them feel like this is truly their space, and in turn their second home.

When preparing for a disaster these spaces can provide more dorm space but can also provide a similar relaxation element to the learning spaces. By being a space that the community designs and interact with, it can become a space that has a homely aura to it, giving a space that people can relax in and come to terms with what has happened.

Chapter 5: Design Development

Proposed Evacuation Center Strategy

Before developing the design there is one aspect of the New York City evacuation plan that needs to be addressed, that being the distribution of the population into its current disaster shelters. Current shelters are set in schools that are within the safe zones and are design to service all the evacuation zones in a 1-mile radius. The issue with this is that the amount of population that needs to be serviced by this one shelter is a more than 15,000 individuals.

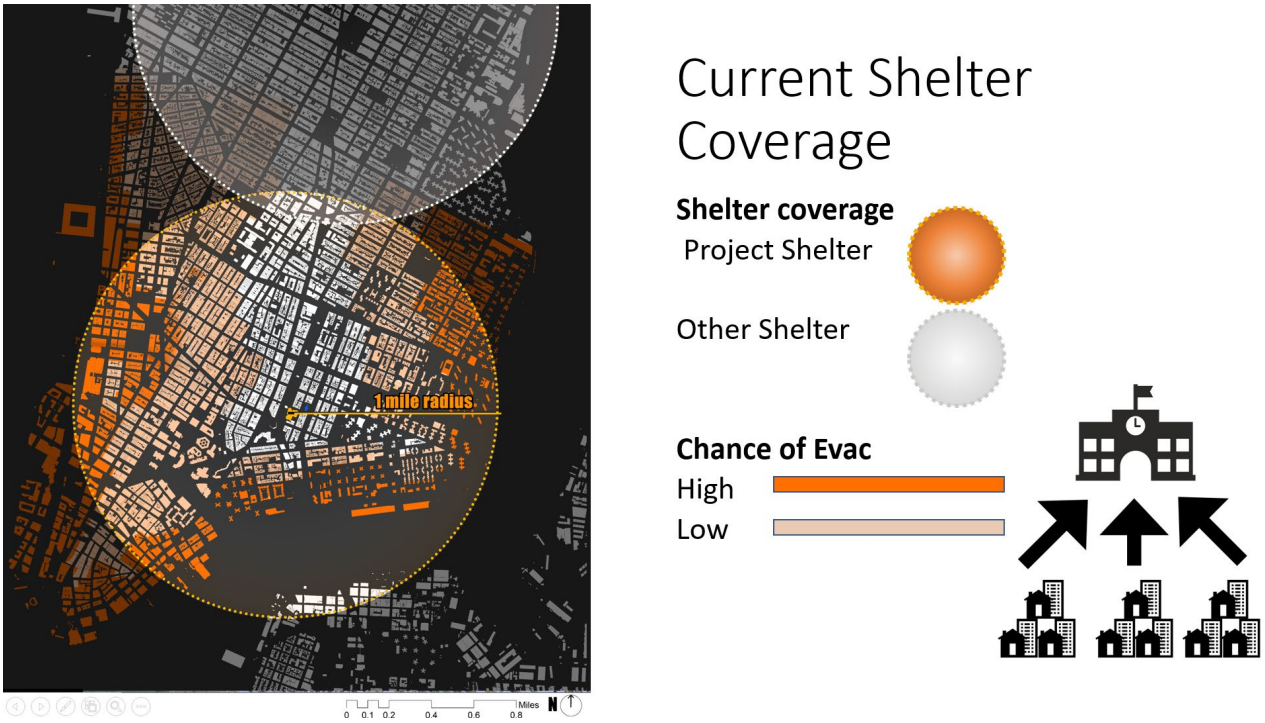

Figure 32: Current Shelter Coverage (Source: Zain Shah)

The issue of overpopulation of these centers coupled with the issue of moving people to and from the centers creates a similar situation to New Orleans and Katrina. To prevent this this thesis proposes an alternative. Instead of having one large center, several smaller centers

should service the evacuation zones. Each smaller center would be able to service a smaller portion of the population, with the overflow being moved to the original shelters. This would provide a tiered system for evacuation, and for spaces for each center to relieve over population to.

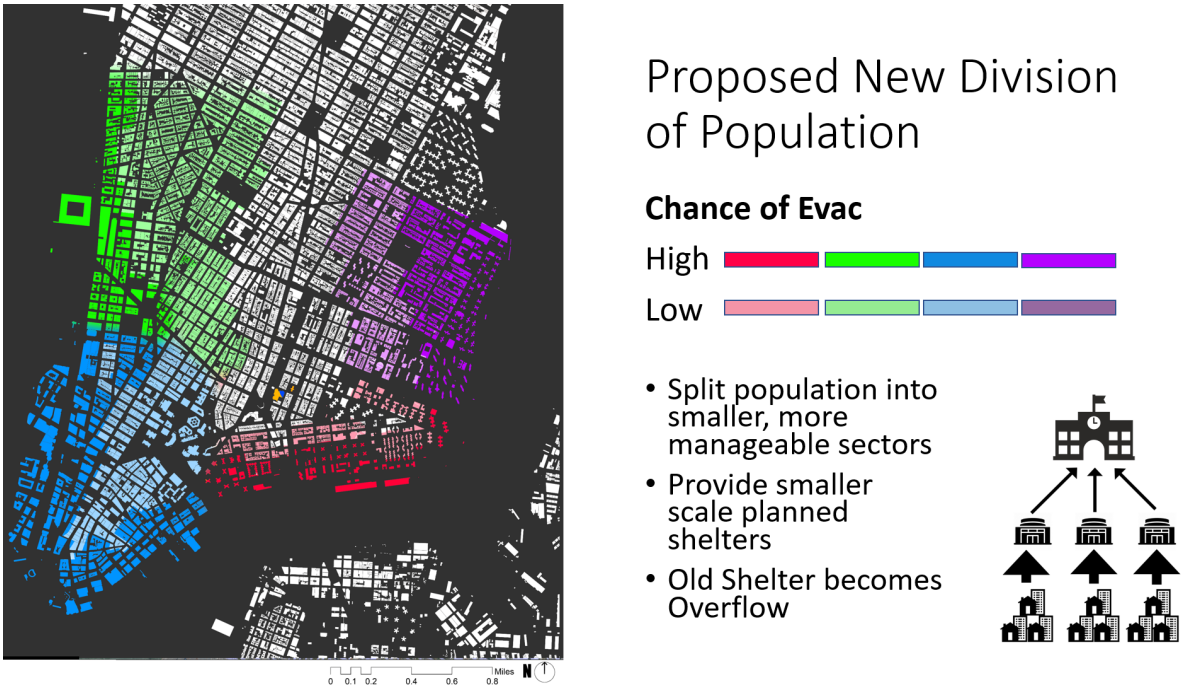

Figure 33: Proposed Shelter Coverage (Source: Zain Shah)

For the purposes of this thesis the center designed here will service the proposed Lower East Manhattan area.

Acknowledgement of Context

One of the first caveats that needs to be discussed about the site is the existing condition. The site of the disaster shelter contains an apartment complex that contains about 150 units. The current housing however did not use its plot of land optimally, which gave

opportunity for the Community Center to be placed. To acknowledge the original, half of the plot of land has been allocated for replacement housing, which should provide a fair amount of space to replace the original context while also freeing space for the shelter.

Figure 34: Elevation showing new housing and shelter (Source: Zain Shah)

Typical Floor

For this facility each space needed to convert from one program to another. For that purpose, each floor has two layouts; one for the community center and one for the shelter. Each floor has a main function that defines its floor, such as a makerspace, a library or an auditorium.

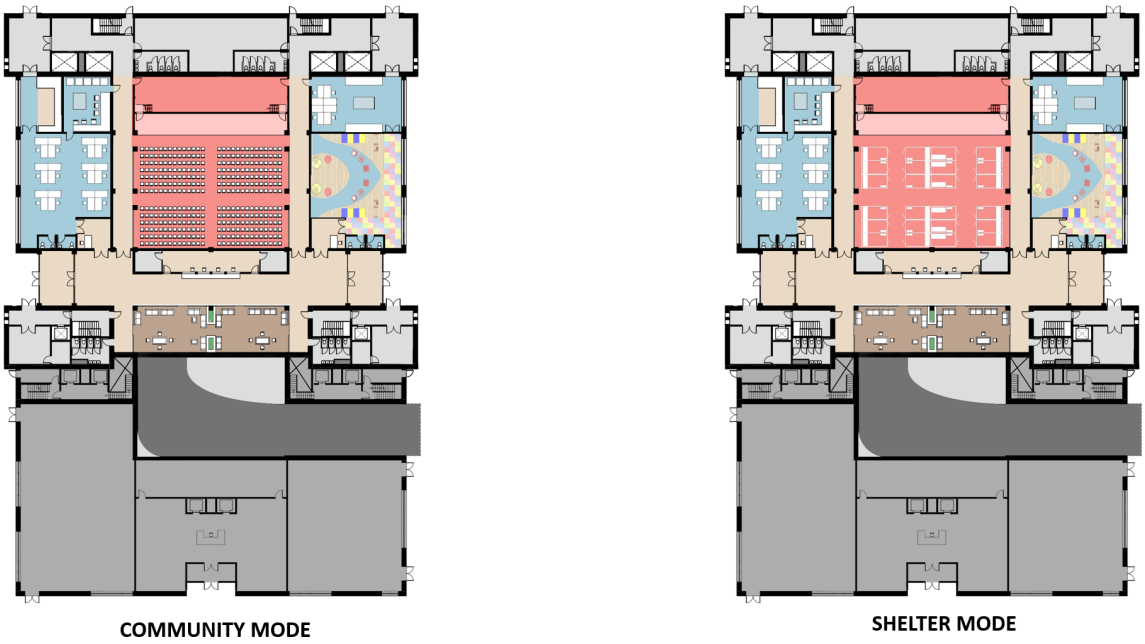

Figure 35:ground floor Auditorium space (Source: Zain Shah)

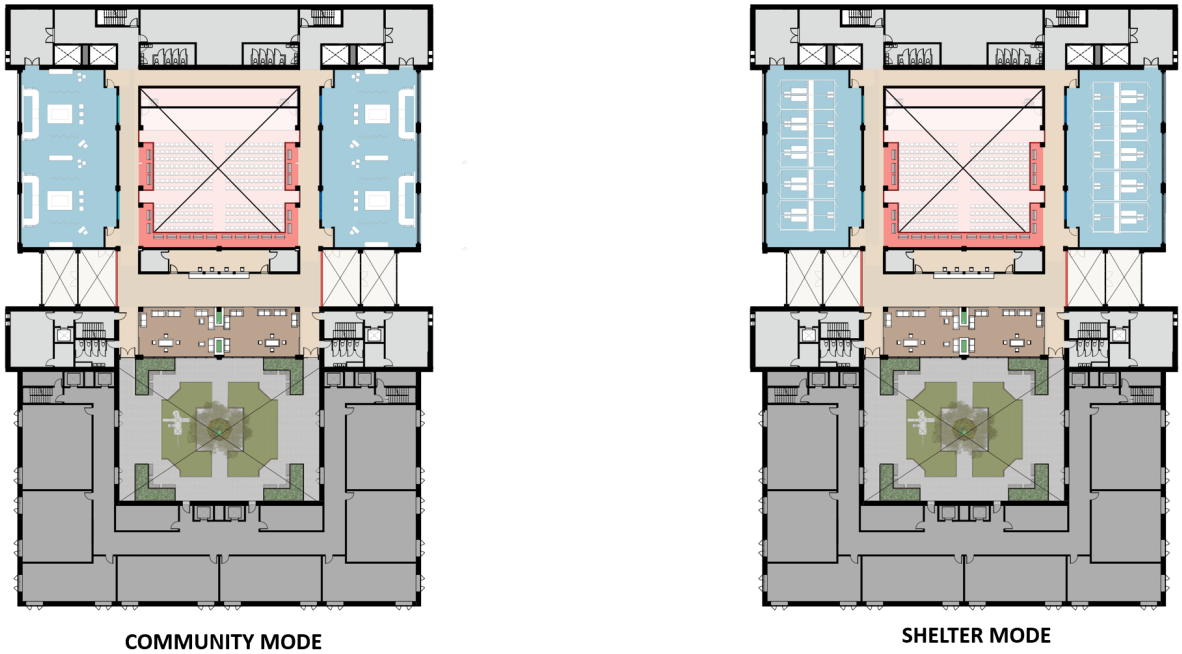

Figure 36: 1st floor exhibition space (Source: Zain Shah)

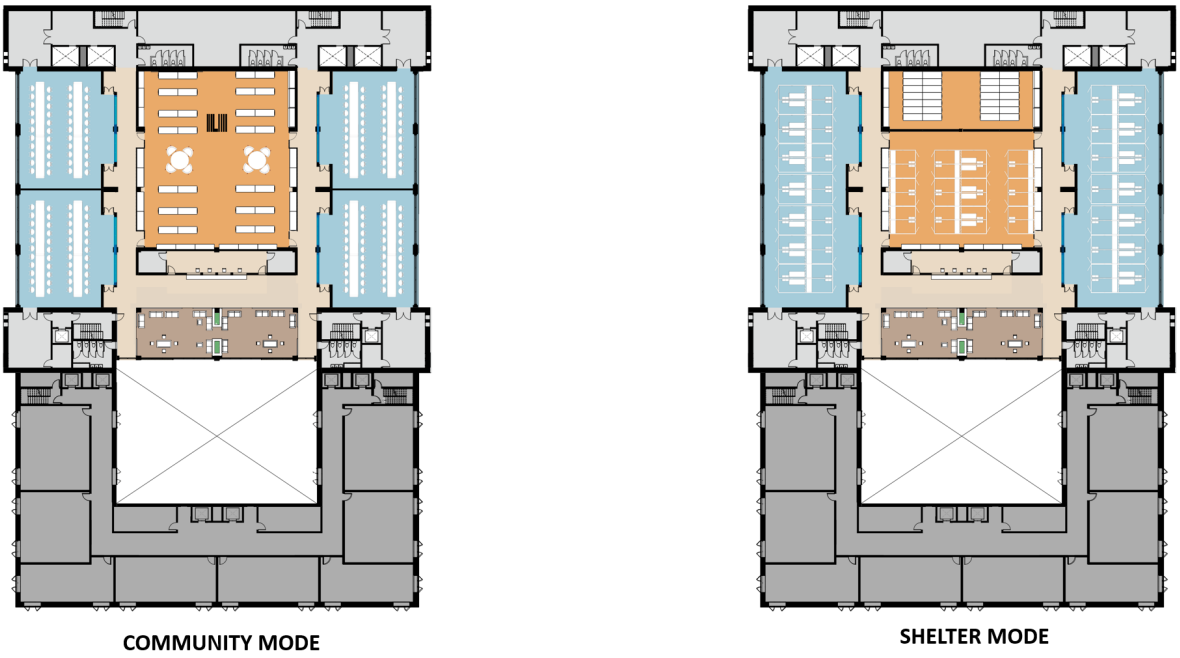

Figure 37: 2nd and 3rd floor library space (Source: Zain Shah)

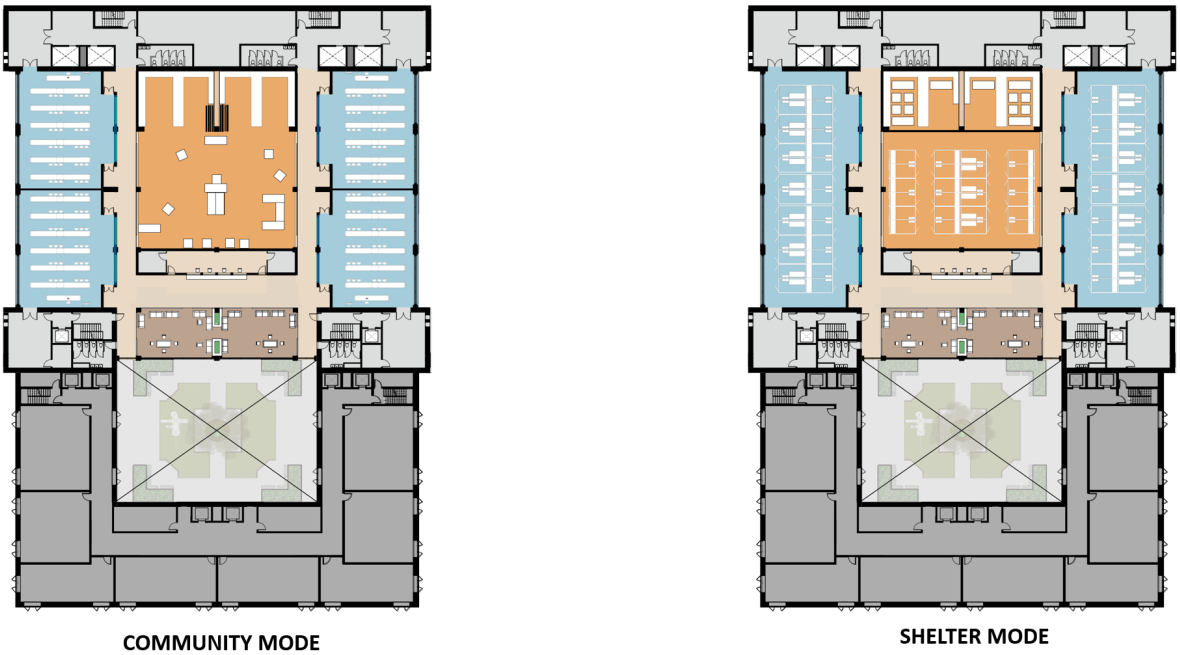

Figure 38: 4th floor makerspace (Source: Zain Shah)

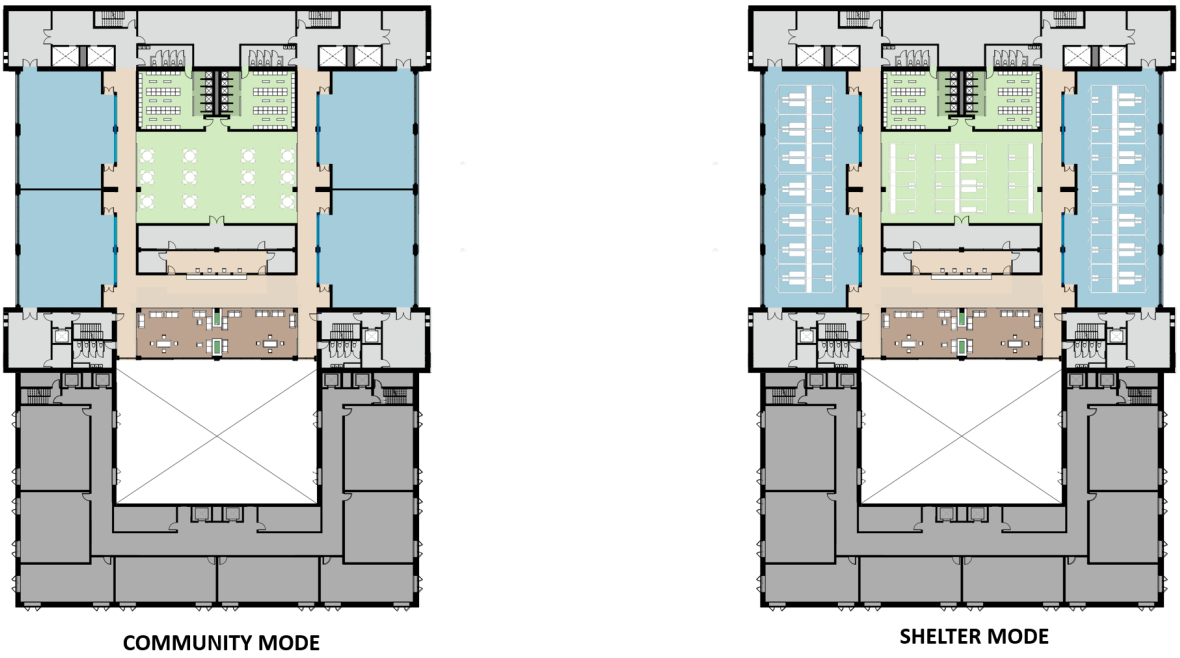

Figure 39: 5th floor locker room (Source: Zain Shah)

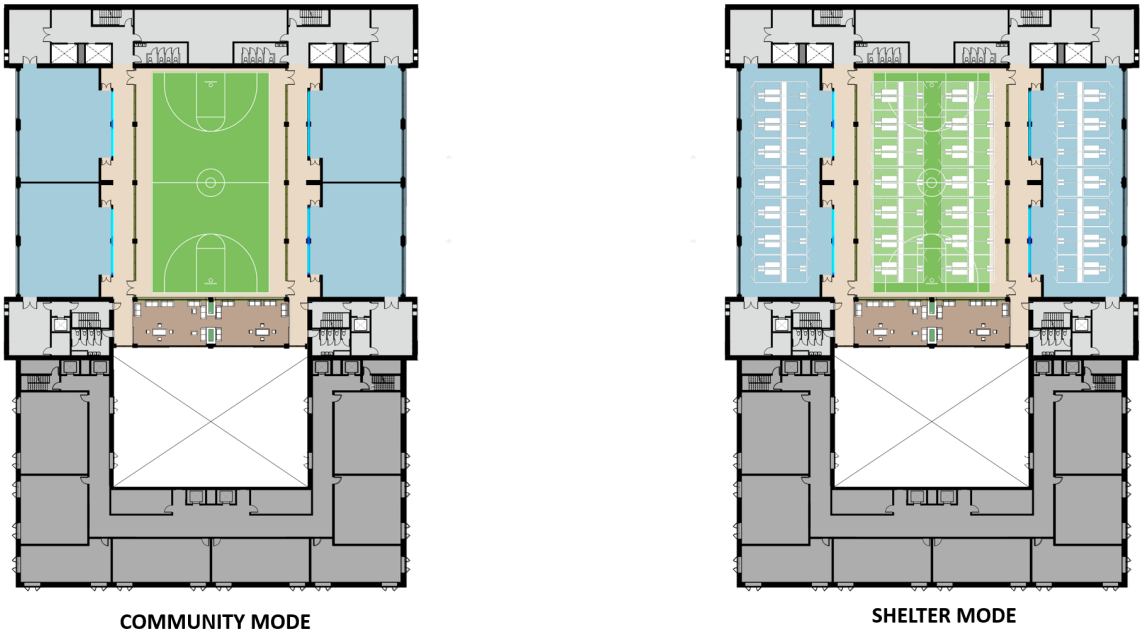

Figure 40: 6th floor Gym (Source: Zain Shah)

To meet the requirements of the facility, that being its transformation from a Community Center to a Disaster Shelter, there needed to be a way for the internal program to shift from phase to phase easily. To that end the precedents of the Domestic Transformer and the My Micro NY project where key in designing a typical floor for this thesis. There were two basic concepts; from the Domestic Transformer came the concept of the compressible space. The idea that the program could be moved and compressed into smaller spaces to make way for other program spaces is an invaluable strategy as it allowed for rooms in the Community Center to turn into Dorm spaces. From My Micro NY came the concept of the Canvas and the Toolbox, where elements of program that provide services, such as restrooms and kitchens, are grouped together as the "Toolbox" to keep fluid "Canvas" spaces, such as the bedroom or dining room, free for movement and change. Using these concepts, a typical floor was devised that promoted quick and fluid transformation of programs.

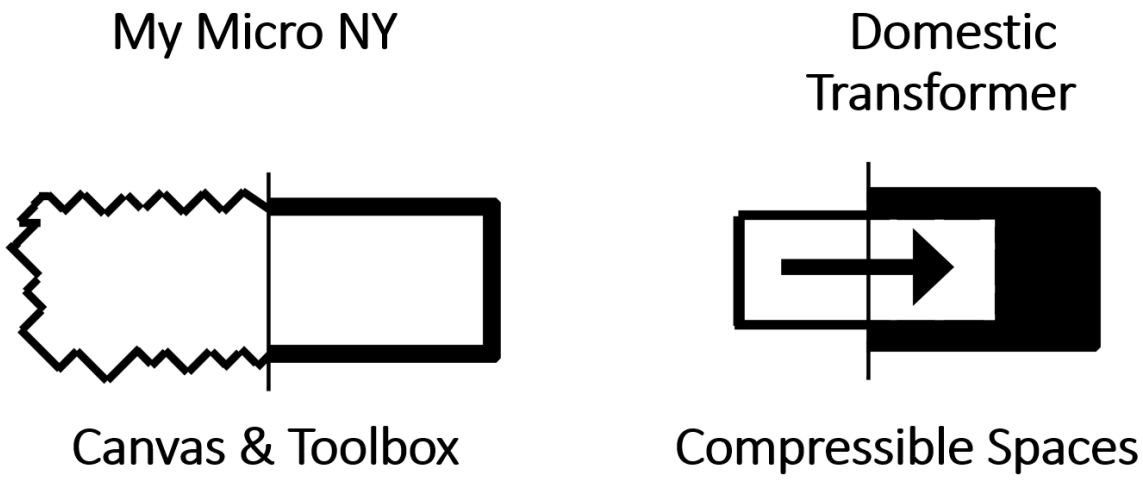

Figure 41: two design concepts for the typical floor (Source: Zain Shah)

The basis of the modular floor was designed to provide program for both the Community Center and the Disaster Shelter. To begin, each floor was designed with the concept of the "Toolbox" spaces at the rear end of the facility and two at each of the forward

corners. Within those poche spaces contained vertical movement spaces such as stairways and elevators, as well as storage space and bathrooms. The rear "toolbox" also provides an area for building systems such as HVAC and possible power generation.

At the center of each floor was also a small administrative space that would provide both a place for users of the building to get information as well as create a security gate to the program behind it. The placement of the vertical movement spaces also created a clear path of movement that helped to define dividing lines for other rooms.

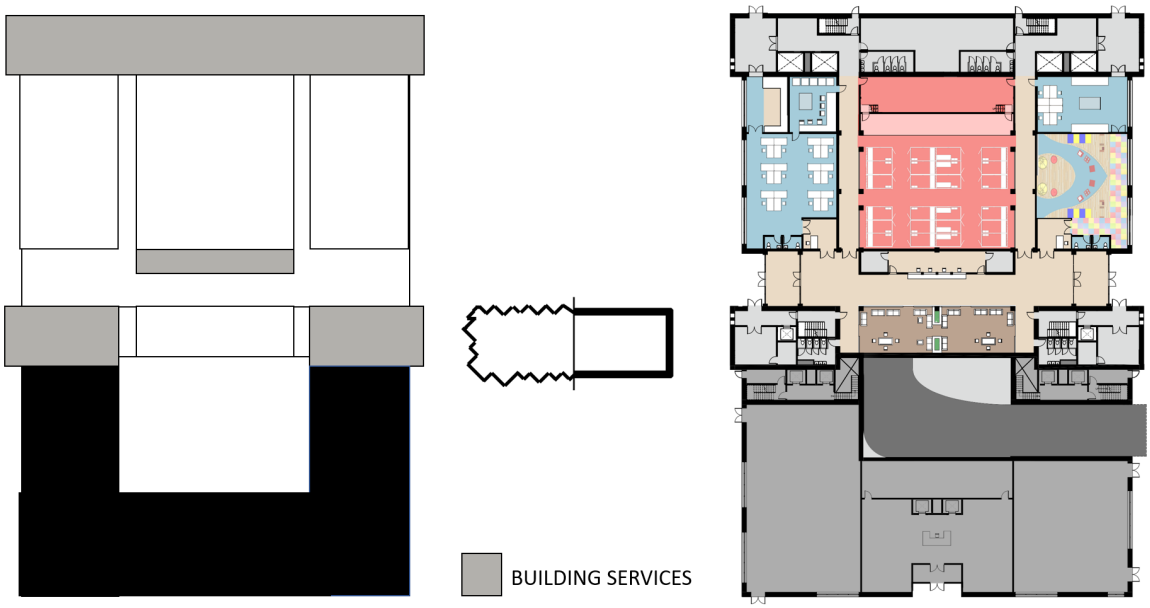

Figure 42: "Toolbox" Spaces (Source: Zain Shah)

Each floor has one main programmatic element as well as 4 smaller programmatic rooms. As an example, the Library floors has one core library room and 4 study rooms on the sides. Each of these rooms can then compress to allow the program to change from its Community Center program to its Disaster Shelter Program. Typically, how this is done is through moving the program into the corner room in the "Toolbox" space for the smaller

rooms and in a side room to the top of the main program space. For the original example of the library the bookshelves move on rails allowing them to compress into the pocket space. This transformation allows for the rooms to be clear for construction of the dormitory units.

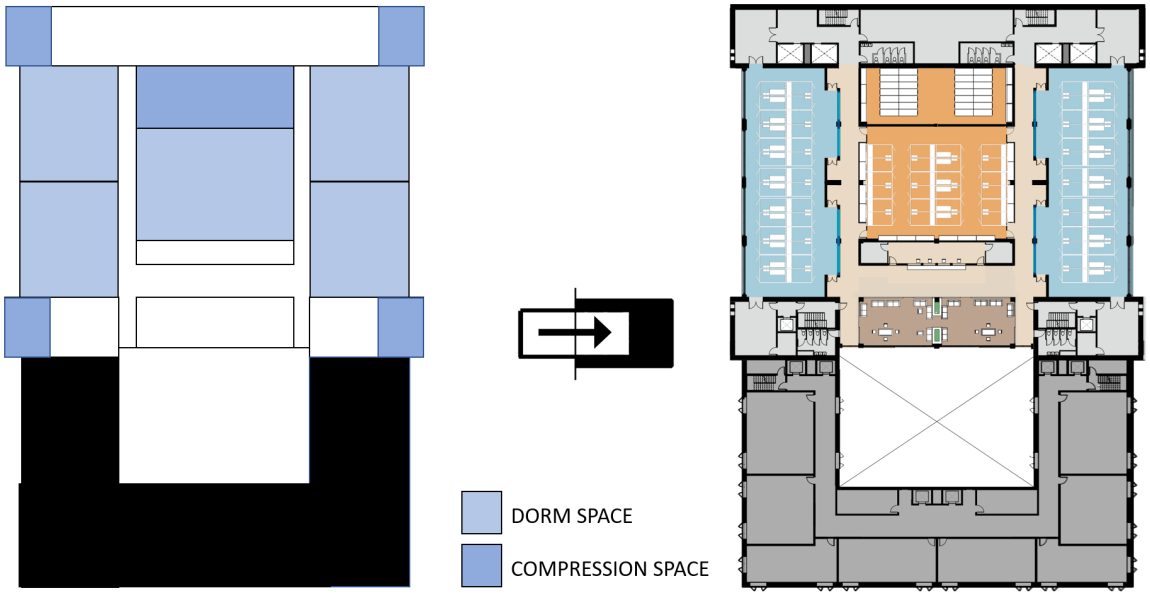

Figure 43: Compression and Dorm Spaces (Source: Zain Shah)

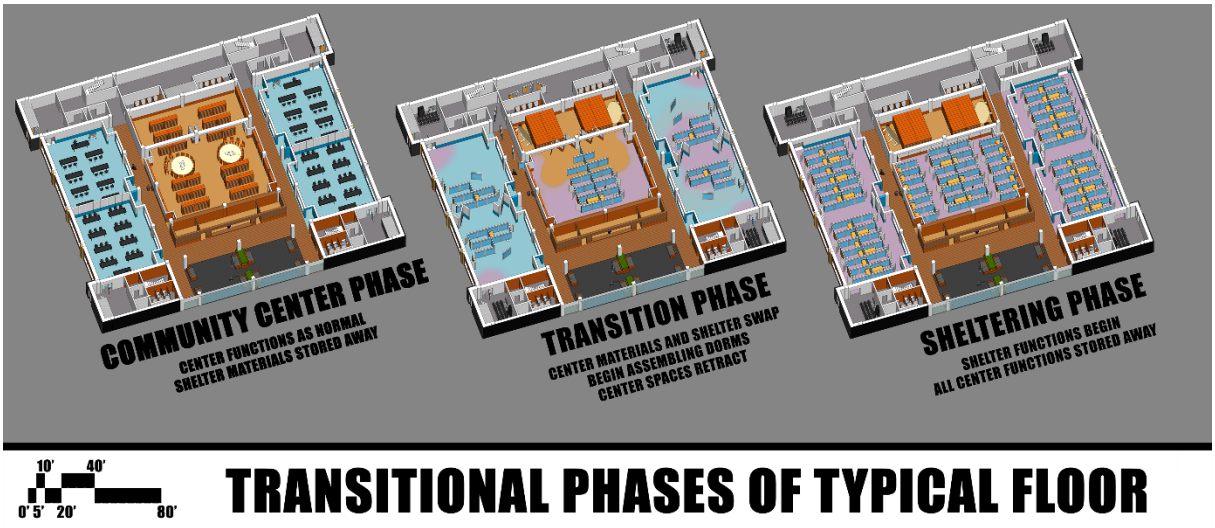

Figure 44: Transition process of floors (Source: Zain Shah)

Each floor also has a small common area that provides a space for relaxation and reprieve from the functional programs in. This place will act as a space that allows individuals to commune with one another in an open space. If an individual is looking for privacy the roof acts as a larger green space that anyone can access. This space can be used for social gatherings in the community center phase and as a space of silent reflection during the disaster phase.

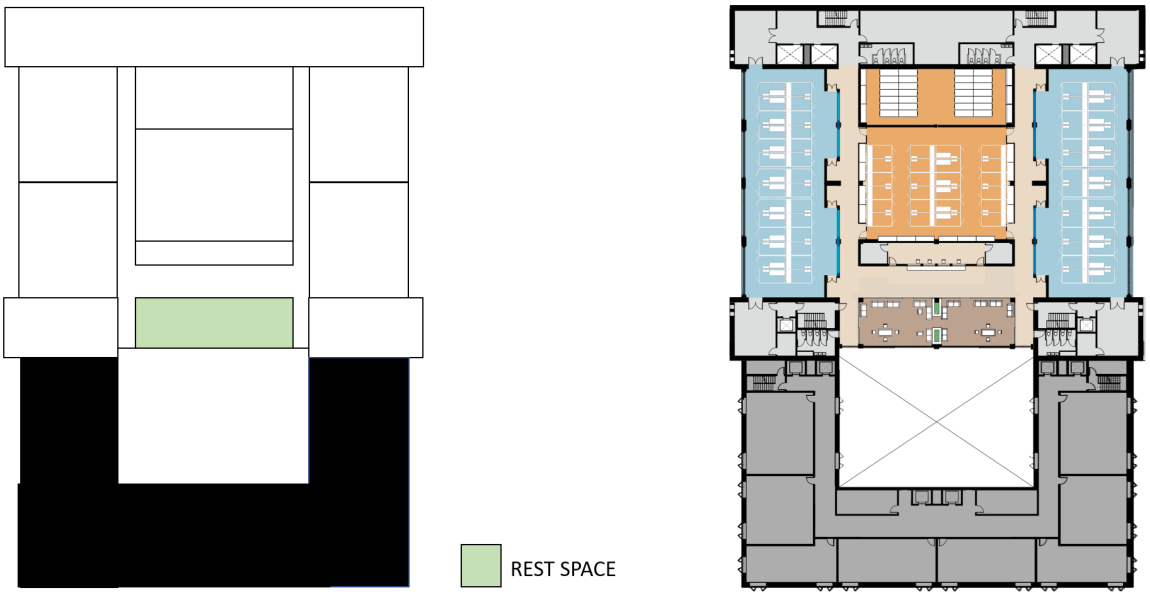

Figure 45: Rest Space (Source: Zain Shah)

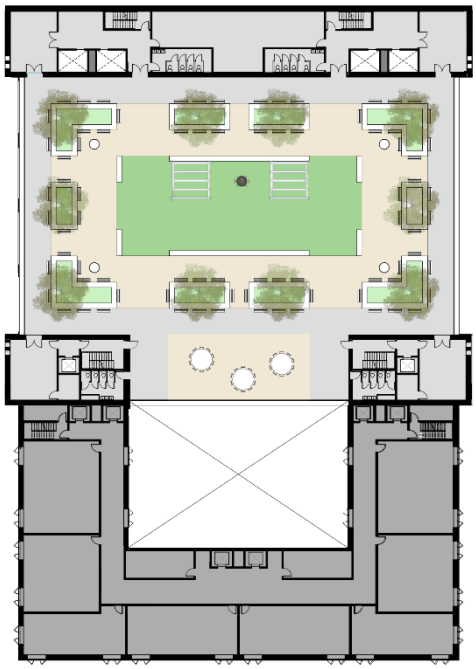

Figure 46: rooftop garden (Source: Zain Shah)

Typical Unit

For the dorm space, each floor has an on-site assembled dorm unit. These dorms act as a modular sleeping space that are stored in the storage areas in the corner of each floor. Each unit begins as movable walls that are move into the space and placed in their designated area. Then, each wall is attached to one another, holding their shape in place.

Each unit also as an assembled on-site bunk bed. These beds are contained in a duffle-bag and are quickly snapped together. Along with the bed each unit has a storage bin for personal effects and resources for those in need, such as blankets, pillows and flashlights. The units are also assembled over power outlets, which would allow ever person to charge electronics such as cellphones and computers.

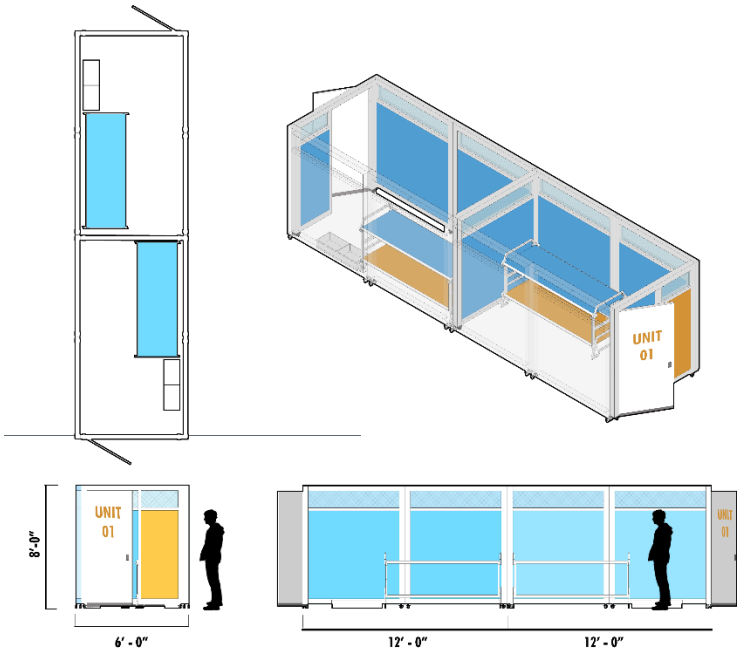

Figure 47: Typical Unit (Source: Zain Shah)

Chapter 6: Conclusion

After developing the facility there were several elements that should be considered when developing a similar center. The first is the development of proper evacuation strategies. When looking at both Katrina and New York both their plans involved large movements of populations into once large Shelter. By making smaller Shelters that instead serviced several smaller populations it will better engage the communities serviced. It will also logistically make it easier to filter populations to safe evacuation areas as opposed to moving them to one singular place of last refuge.

Secondly, facilities like these need to be able to transform quickly by having on-site options to do so. In this thesis strategies such as compressing program and building on-site dormitories helped to quickly an easily convert program. Any facility developed similarly should find successful strategies to do similar.

Finally, facilities need to find solutions to create spaces for relaxation and services. In the program developed here Space such as the roof and the Common Room allowed for people to find spaces to grieve and spaces to communicate with other people. Doing so helps to engage the mental health of the Shelter's population. By also providing spaces such as the Locker Room showers and the Makerspace's Tools people are also able to have useful services to make them feel comfortable while they are sheltered.

These factors should be considered for future developments of centers. The goal of a Disaster Shelter is to protect its population, but these spaces only protect people on a physical level. By thinking of these factors people are helped on a mental and emotional level, which shows that developers care about those who have been affected by an evacuation.

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